THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

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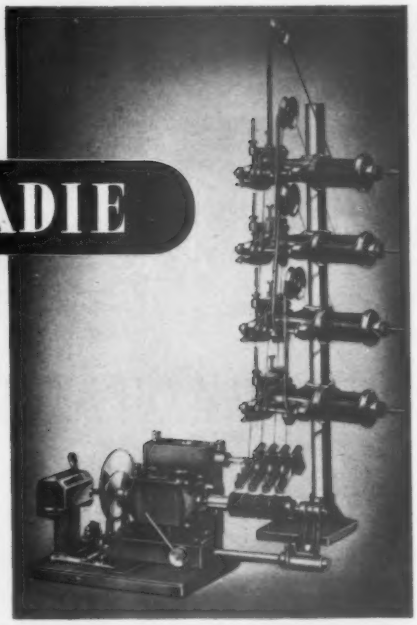

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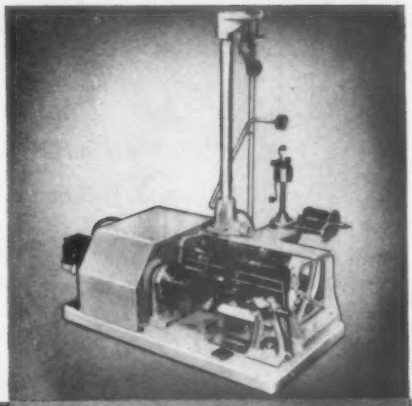

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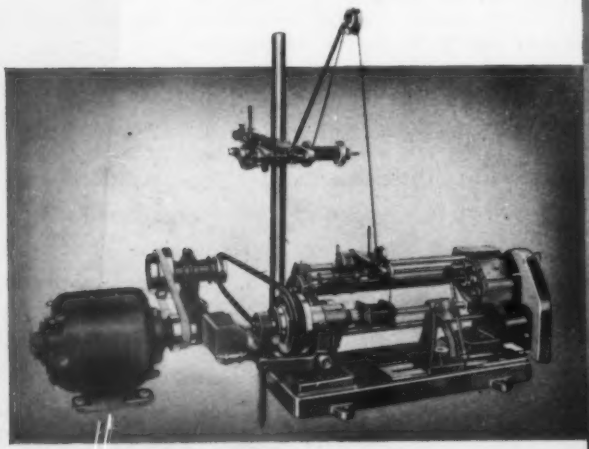

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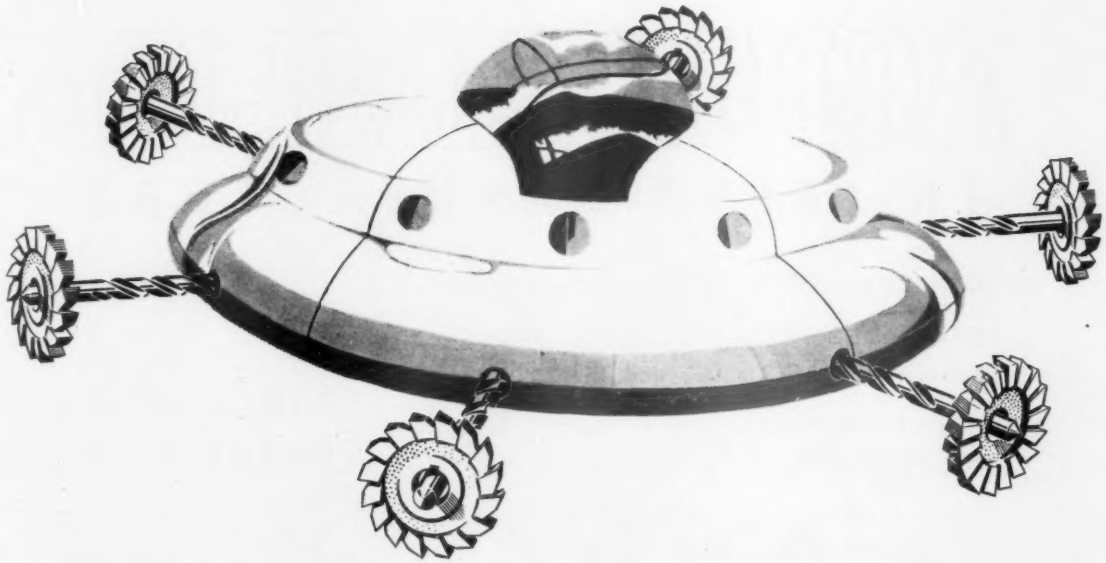

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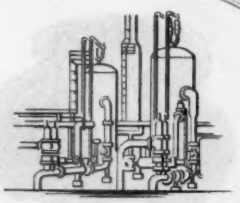

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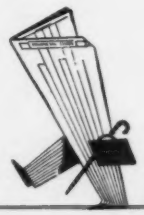

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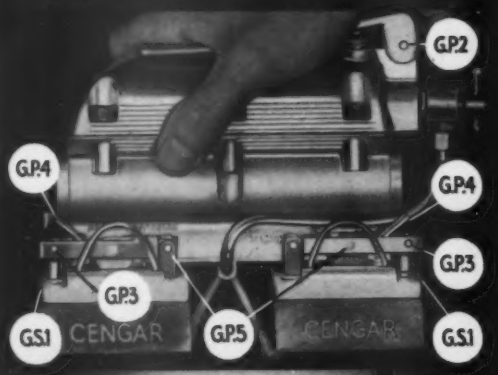

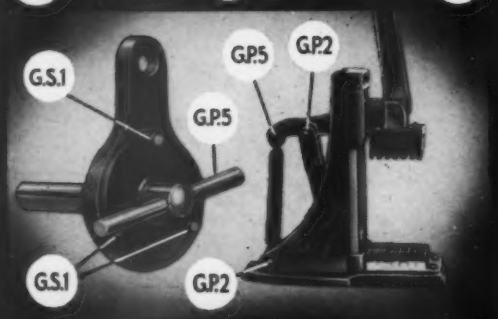

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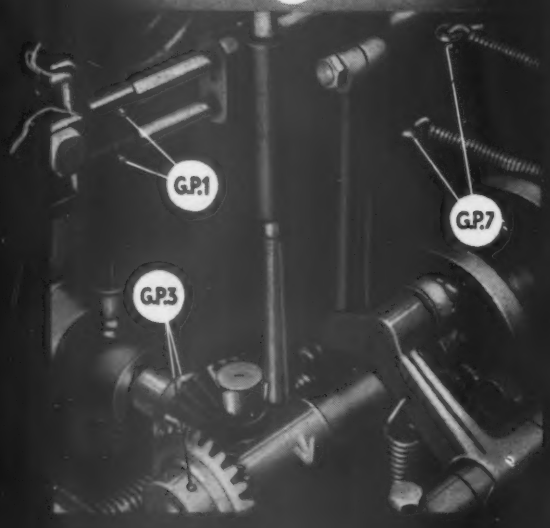

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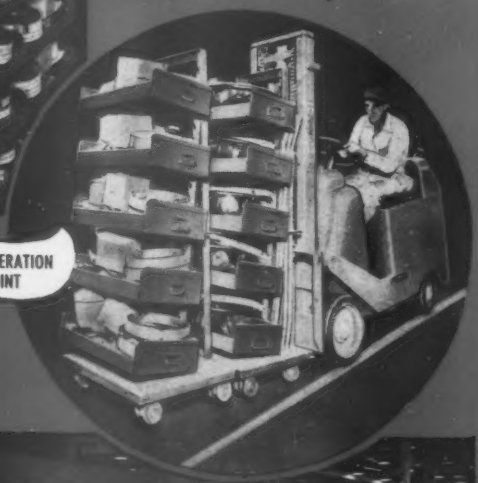

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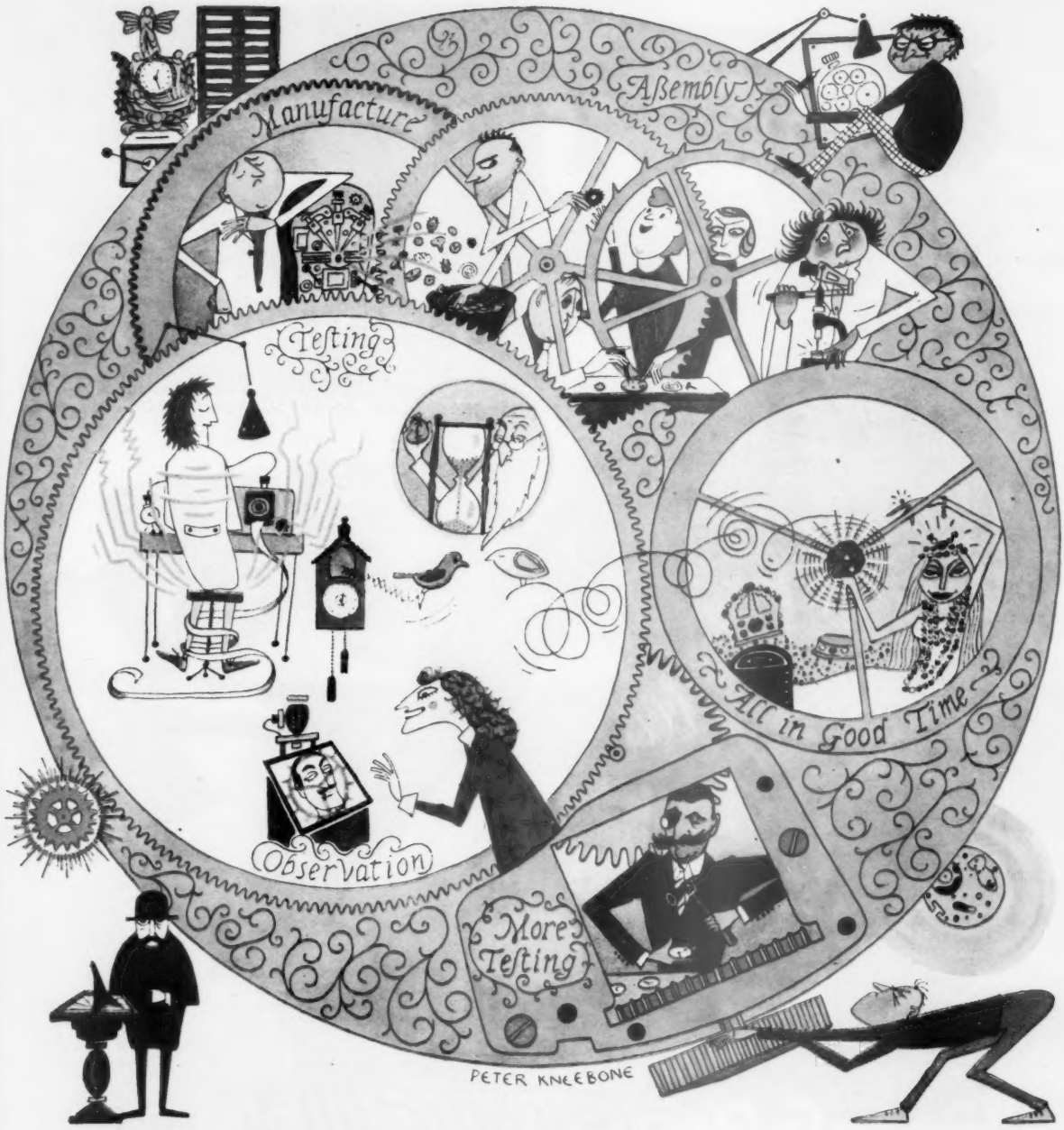

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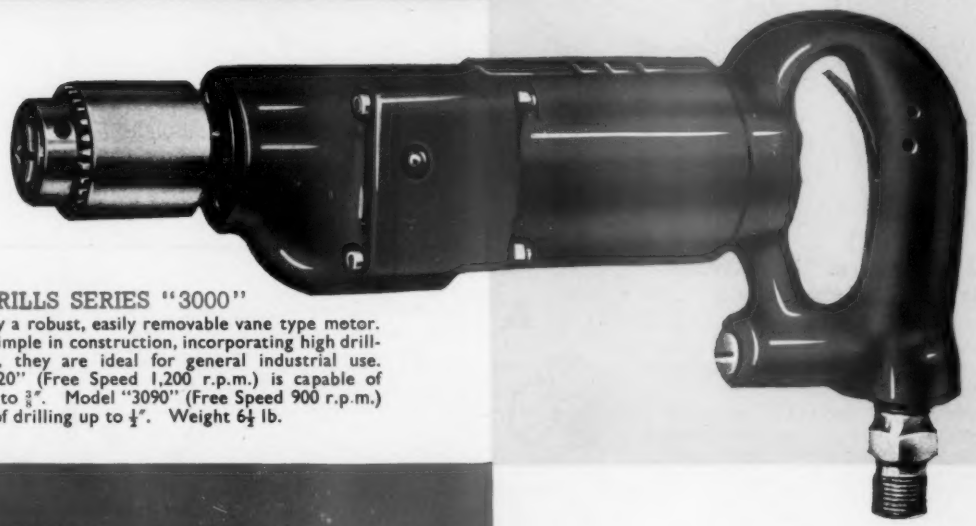

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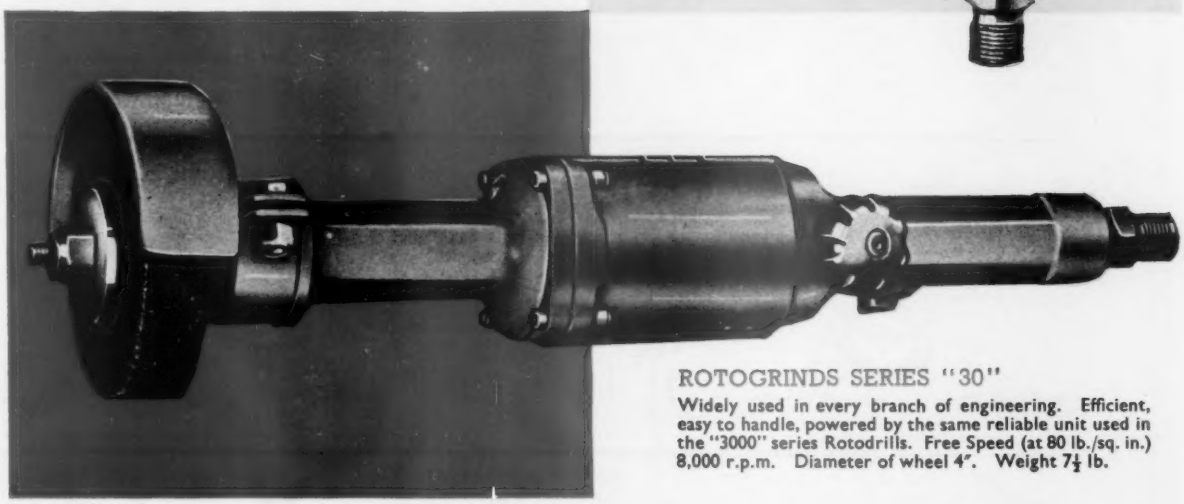

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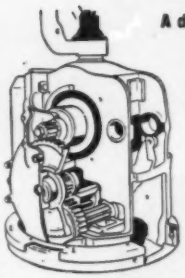

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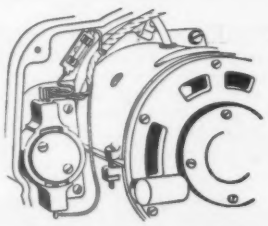

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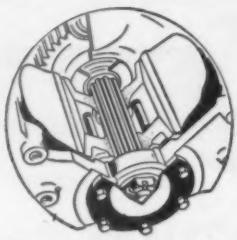

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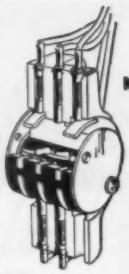

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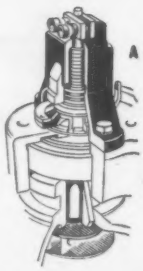

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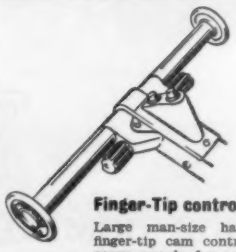

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P272

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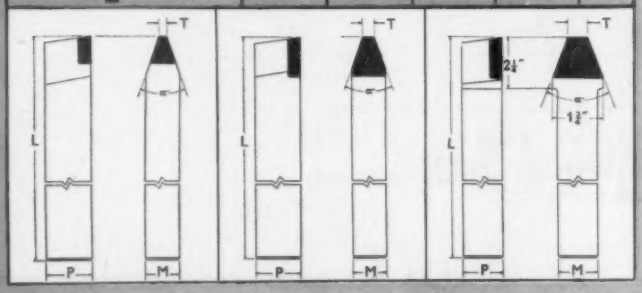
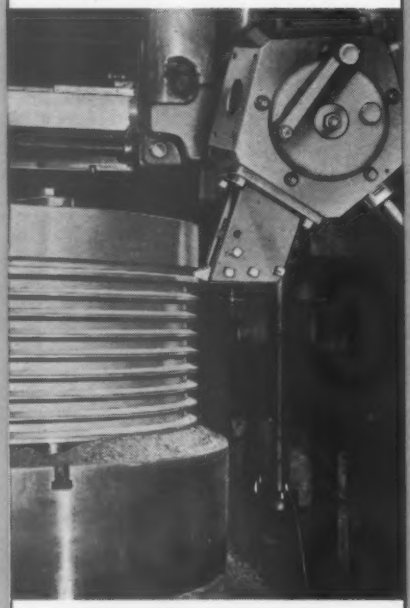
GROUP M BELT SIZE ⅜"×$\frac{15}{32}$"	3200	32°	0.139	1	⅜	6
	3202	34°	0.127	1	⅜	6
	3204	36°	0.115	1	⅜	6
	3206	38°	0.103	1	⅜	6
	3208	40°	0.090	1	⅜	6
GROUP A BELT SIZE ½"×$\frac{5}{16}$"	3210	32°	0.197	1	⅜	6
	3212	34°	0.182	1	⅜	6
	3214	36°	0.167	1	⅜	6
	3216	38°	0.151	1	⅜	6
	3218	40°	0.136	1	⅜	6
GROUP B BELT SIZE ¾"×$\frac{11}{32}$"	3220	32°	0.268	1	⅜	6
	3222	34°	0.249	1	⅜	6
	3224	36°	0.229	1	⅜	6
	3226	38°	0.210	1	⅜	6
	3228	40°	0.190	1	⅜	6
GROUP C BELT SIZE 1"×$\frac{11}{32}$"	3230	32°	0.345	1½	1	8
	3232	34°	0.320	1½	1	8
	3234	36°	0.293	1½	1	8
	3236	38°	0.265	1½	1	8
	3238	40°	0.238	1½	1	8
GROUP D BELT SIZE 1¼"×½"	3240	32°	0.575	1½	1½	10
	3242	34°	0.543	1½	1½	10
	3244	36°	0.509	1½	1½	10
	3246	38°	0.476	1½	1½	10
	3248	40°	0.443	1½	1½	10
GROUP E BELT SIZE 1½"×$\frac{13}{32}$"	3250	32°	0.683	1½	1½	10
	3252	34°	0.643	1½	1½	10
	3254	36°	0.603	1½	1½	10
	3256	38°	0.563	1½	1½	10
	3258	40°	0.522	1½	1½	10



Here is an example of vee-groove production with Wimet tools



This cast iron vee rope pulley is produced on a 48" Webster and Bennett Boring and Turning Mill. Eleven formed grooves are individually machined from the solid.

Catalogue ST88 gives full details of these tools. Write for a copy to-day.

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The Institution of Production Engineers Journal
VOL. 34 NO. 6 JUNE, 1955

Automation in the United Kingdom

THE word "Automation" has now been in use long enough for most people engaged in industry to comprehend it, and for a number of laymen to have some vague idea of its meaning. In its simplest form, the word means a linking together of a number of manufacturing processes, previously carried out separately, so that the operations can be performed in a continuous series controlled from one point and untouched by the human hand.

Before we consider the extension of this principle into industrial activities to a point where we might have an Automatic Factory, let us spend a moment or two examining the word itself. There is a marked reluctance in Great Britain to accept this word into our vocabulary: it is being used now, not by popular consent, but simply because no one has been able to invent a better or more expressive word. Other words have had a similarly difficult childhood—"Productivity" is one. No one liked this word when it first became current and few people really understood it, but it has now been accepted into our vocabulary and is in general use. For want of a better word, "Automation" will probably likewise be accepted into our vocabulary. Mr. F. G. Woollard, M.B.E., in the bibliography on "Automation" published in the February, 1955, issue of the Journal, made a valiant attempt to invest "Automation" with legitimate parents. He said:

> "The word 'automation' was coined by Del. S. Harder, Vice-President of Manufacturing at the Ford Motor Company, U.S.A., in 1940. It was at first used to describe the automatic transfer of work-pieces from machine to machine, but is now being applied in more general sense to automatic operation. This word has a respectable, if mixed, parentage. It is derived from the Greek automatos, self-moving: AUTOS, self and a stem MAT-, moving. To this is added the Latin suffix ION, being or state of being."

There is nothing fundamentally new in the conception of automation. Man has always endeavoured to lighten his burdens by augmenting the power of his muscles. In the earliest days he used the wheel and the lever, his own muscles providing the basic power. The utilisation of water and steam made enormous additions to muscle power, and the discovery of coal made abundant power available. The availability of power tapped an endless stream of human invention.

Mechanical aids of every kind were invented by men to increase their productive capacity and their application to large scale production brought about the Industrial Revolution.

The application of electrical energy was another tremendous advance and, to the purely mechanical devices of the Industrial Revolution were added electrical and electro-mechanical machines. The invention of the thermionic valve and the progress of its attendant science of electronics have opened new doors. These recent advances, coupled with the possibilities inherent in the development of nuclear energy, seem to suggest that mankind is about to take another tremendous leap forward comparable with the first Industrial Revolution. The combination of electronics with electrical and mechanical as well as hydraulic and pneumatic devices has now made practicable, operations which until recently were possible only in theory. The very rapid advance of this combination of technological and scientific development has given rise to industrial activities which are now generally referred to as "Automation". Some of the outstanding features of automatic production are the precise control of operations; the automatic transfer of the product from one stage of manufacture to the next; "built-in" inspection and quality control, with the consequent reduction of scrap and the elimination of unnecessary or unproductive functions.

Automation has been adopted in the United Kingdom on a wider scale than is generally believed to be the case. Outstanding examples are the great oil refineries which have been built in the United Kingdom during the past decade and the new steel sheet rolling and tin-plate mills in South Wales. The chemical industry is increasingly adopting automation in the manufacture of substances, plastics, synthetic fibres and the like. Automation is also being introduced in the glass industry and textile manufacture.

Developments in the metal-working engineering industries are not so far advanced, except in the manufacture of motor vehicles where automation is firmly established. It is interesting to reflect that by far the greater part of automatic machinery used by other industries is made in the engineering industries which are still using, in the main, what can be called traditional methods.

Many people consider that the principles of automation are not capable of being applied to batch and jobbing work. There are, however, definite signs that various stages of automation are capable of being applied to batch and jobbing work with great benefit to the industries concerned. At least one major aircraft company is making a close study of the application of automation to aircraft production.

There appears to be little or no evidence to support the view that the widespread application of these great scientific and technological developments in British industry might cause unemployment. Great Britain today is suffering from an acute labour shortage and the vital statistics suggest that the situation may grow worse as time goes on. At the present time, Great Britain is still very wasteful in the utilisation of her manpower resources. Men are performing operations manually which can be done much more efficiently and quickly by machinery. A vast amount of clerical labour is employed in doing calculations which can be done more accurately and in a fraction of the time by electronically controlled machines.

It is significant that industrial performance in the United States of America is better than in the United Kingdom, approximately in the same proportion as the amount of power available per man, which is about two and a half times more in the United States than in the United Kingdom. The introduction of automation offers a means of substantially increasing output per man. The products of Great Britain sell all over the world but prices must be kept down if trade is to be maintained. A reduction in the labour cost in each article produced will enable selling prices to be reduced, so that the volume of business can be increased. Business, however, can only be increased if the output of our factories is likewise increased. Today many orders are being lost because of the inability of firms to offer and maintain attractive delivery dates and prices.

New employment is being created every day. During the past year capital expenditure schemes totalling many hundreds of millions of pounds have been announced by both public and private undertakings. It is not just a coincidence that at the same time the "Automatic Factory" and "Automation" have become widely discussed, since many of the new factories will be equipped with automatic production devices and many more will be engaged on manufacturing this new equipment.

Any developments which will help our labour force to increase the volume of production and so raise the earning power of all, are wholly to be desired. Enlightened trade unionists recognise this and see clearly that the trades unions' role should be to encourage their members to welcome the introduction of automatic production devices, as greater productivity will ultimately lead to greater prosperity.

These and other aspects of Automation will be explored at the Institution's Conference being held in Margate from June 16th-19th.

New developments in production technology may one day make it possible for us all to work fewer hours. Before that happy stage is reached, let us hope that man will have learnt to live in peace with his fellows and so be able to enjoy his new found leisure.

COMPRESSED AIR IN AIRCRAFT PRODUCTION—A USER'S EXPERIENCE

by W. E. WRIGHT,
A.F.R.Ae.S., A.M.I.Mech.E., A.M.I.Prod.E.

Presented at a Conference arranged by the Cornwall Section of the Institution, and held at Camborne, 13th/14th April, 1955.

Mr. Wright

Mr. Wright was educated at Skegness School and Derby Technical College, where he gained the Ordinary and Higher National Certificates in Mechanical and Automobile Engineering, with distinctions in all subjects and also obtained a Whitworth Prize and a National Certificate Prize.

He served an engineering apprenticeship at the Derby Works of Rolls-Royce Ltd., subsequently becoming a Jig and Tool Draughtsman in their Tool Drawing Office.

He took a position as Jig and Tool Designer with The Bristol Aeroplane Co. Ltd. in 1936, was promoted Section Leader in 1939 and took charge of the Jig and Tool Drawing Office of the Hawthorn Engine Factory in 1943.

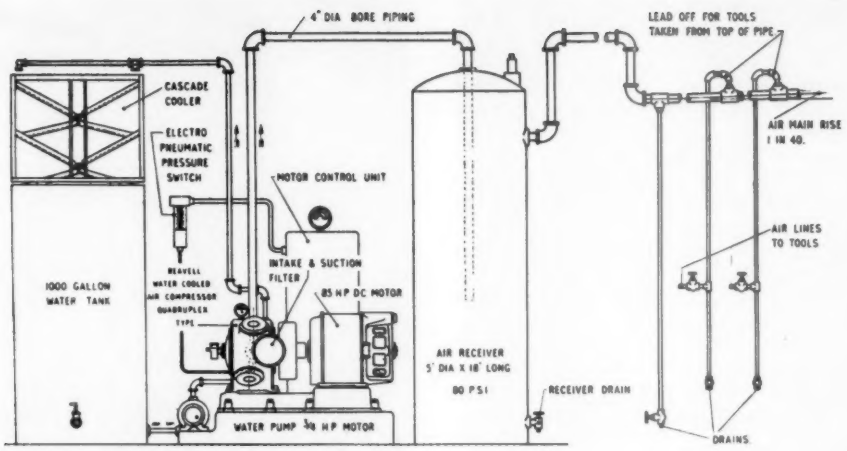
He became Chief Planning Engineer in the Development Department in 1944. In 1947 he became Chief Jig and Tool Draughtsman in the Engine Production Department and was promoted to Chief Planning Engineer of the same Department in 1951.

He was admitted an Associate Member of the Institution of Mechanical Engineers in 1938, an Associate Fellow of the Royal Aeronautical Society in 1942 and an Associate Member of the Institution of Production Engineers in 1948.

THE general engineering industry has employed compressed air as a power medium for many years, but its adoption by the aircraft industry is comparatively recent. In this short period, however, we of the industry have applied it with marked success in our production shops, manufacturing processes and development activities and it has now taken its place with the other three power media (i.e. mechanical, electrical and hydraulic) to aid our production techniques. Its advance in this latter field, as distinct from that of research is due primarily to the range of proprietary control units, valves and other ancillary equipment now obtainable "off the shelf" from numerous suppliers.

Since aero-engines depend on the consumption of large quantities of air for their performance and efficiency (particularly the gas turbine and ram jet engines), we employ air to an ever greater degree to simulate flight conditions for testing assembled aircraft and engine components. In this vast sphere (which is peculiar to the aircraft industry) the demand is for more and more air. The flow requirements are huge and we talk in terms of "mass flows" of the order of hundreds of pounds per second. For this work the compressors, receivers, ducting, valves and other equipment necessitate specialised study and their design and application is complex and expensive. We shall be reviewing some of these interesting applications later.

All the compressed air equipment under review in this Paper is in current use in the works of my Company at Bristol and at this point I would


4" DIA BORE PIPING
LEAD OFF FOR TOOLS TAKEN FROM TOP OF PIPE
CASCADE COOLER
ELECTRO PNEUMATIC PRESSURE SWITCH
MOTOR CONTROL UNIT
AIR MAIN RISE 1 IN 40.
AIR LINES TO TOOLS
1000 GALLON WATER TANK
REAVELL WATER COOLED AIR COMPRESSOR QUADRUPLEX TYPE
INTAKE & SUCTION FILTER
85 H.P. DC MOTOR
AIR RECEIVER 5' DIA X 18' LONG 80 P.S.I.
RECEIVER DRAIN
WATER PUMP ½ H.P. MOTOR
DRAINS

DIAGRAMMATIC ARRANGEMENT OF COMPRESSOR INSTALLATION AND PIPING

Fig. 1. Typical compressor installation.

like to outline very briefly the layout of our factories so that the locations mentioned in the lecture will be familiar to you.

Typical Compressor Installations in the Production Workshops

The plant at Bristol devoted to the manufacture of aircraft consists of three separate factories: the airframe factory at Filton, the engine factory at Patchway and the sheet metal fabrication factory at Rodney. Each factory is responsible for its compressed air installations and, therefore, there are numerous types of compressors in use. Two main types, however, supply air to the workshops and other ancillary plant, disregarding the test and research departments. Broom and Wade TS1A, double-acting, two-stage compressors with inter-cooling between stages are installed at Filton and Rodney and Reavell Quadruplex QR9 × 6 single-stage, single-acting water-cooled compressors are employed at Patchway.

I can best describe each air circuit as a link-up in close circuit with all air receivers in the Factory with the exception of the research side, so that the pressure is practically constant at any "take-off" point throughout the plant. This also enables any receiver to be isolated, inspected, cleaned and its feed compressor serviced, at a moment's notice. Fig. 1 shows a typical compressor installation in the engine factory; there are 21 of these installations in the complete circuit. The Quadruplex compressor is driven at 600 r.p.m. by means of a direct-coupled 85 h.p. DC motor and at this speed produces 400 cubic feet of air per minute which is fed into an air receiver of 353 cubic feet capacity.

At a pressure of 80 p.s.i., a preset electro-pneumatic pressure switch cuts out the driving motor but brings it into operation again when the pressure falls to 65 p.s.i. As the receivers are connected in series, one pressure switch controls all motors in unison. Water to cool the compressor is supplied from a 1,000 gallon tank, above which are mounted cascade-type coolers receiving hot water direct from the compressor. Four-inch diameter pipes convey the air from the compressor to the receiver and from the receiver to the main overhead shop and feed pipes. The feed pipes are inclined upwards at approximately 1 in 40 and have a water drain fitted at the lower ends. The lead-off for tools, etc., is taken from the top of the pipe to ensure a supply of the dryest air. We have also found it necessary to fit drain cocks in the end of every feed drop pipe but only use water traps for special applications where very dry air is essential, in which case "Victor Aridifiers" are fitted.

I can now pass on to pneumatic applications, dealing with each factory in turn but leaving the test and research departments of the engine factory until later, as I feel that the latter are worthy of special note.

Pneumatic Applications in the Production Workshops

During the past three years the Company has built a modern precision steel foundry for producing castings to close limits by the "lost wax" and "shell moulding" processes. The foundry has been semi-mechanised and air equipment is built into some of the key machines. Fig. 2 shows a wax injection machine which is a typical example. The wax is contained in a heated thermostatically controlled header tank mounted above the nozzle and is pressurised from the shop airline through a control

valve set at about 30 p.s.i. In the centre of the header tank is a wax cylinder which is operated by an air cylinder above it, open to air line pressure and having a build-up of 5 - 1 on the wax cylinder, thus giving a maximum wax injection pressure of approximately 400 p.s.i.

A hydraulically operated machine table lifts the mould to the injector nozzle and holds it in that position throughout the machine cycle. The wax tap is then opened automatically and the wax forced into the mould under the low pressure in the header tank. When a predetermined time has elapsed, the air cylinder is set in motion automatically and further wax is forced into the mould under *high* pressure. After a short period of time, the wax tap is closed and the mould table and air cylinder return to their original positions, thus completing the cycle.

The slurry mixer used in the subsequent process comprises a circular tank in which are two opposed discs, each having a set of radial vanes disposed at an angle of 45° relative to the other. An air cylinder controlled by a solenoid-operated air valve, imparts a reciprocating motion to the spindle on which the discs are mounted, thus producing a contra-rotating mixing action of the slurry.

A small capacity carbon-arc furnace of our own design is shown in Fig. 3. With the mould clamped on the top of the furnace, the furnace is inverted for pouring. When the mould is filled, an air pilot valve is opened automatically and air pressure is built up in the furnace to some 10 to 15 p.s.i.

Fig. 3. Carbon arc furnace, in inverted pouring position. A—cam; B—airpilot valve.

Fig. 2. Wax injection machine. A—air cylinder.

The application of this low air pressure enhances the flow of metal and produces a more homogeneous casting, especially in the thin section. This air pressure is also employed to remove any metal or slag remaining in the furnace previous to recharging.

The machine illustrated in Fig. 4 is employed in the production of shell moulds from precision metal master-moulds and has several operation stations linked together by roller tracks arranged in a square, with the operator in the centre.

Referring to Fig. 4, station "A" is a booth for spraying the hot moulds. It incorporates a rotating table, the angle of which can be varied through 45° by a remotely controlled air cylinder. The side doors of the booth are also operated in a similar manner.

At station "B", the mould is invested in resin-bonded sand whilst held in position by an air clamp. A pre-set electrical time-control mechanism opens a valve which sets an air cylinder in motion, turning the section of the track carrying the clamped mould through 180°. When all non-invested loose sand has fallen into a tray below, the track returns to its original position, after which the air clamp is released. The mould is then pushed along the track to station "C", where a remotely controlled air ram pushes the mould on to an endless belt travelling through a gas-fired curing oven. Emerging through the oven exit, the mould trips an air switch which actuates another air ram to push it to the next operation, "D".

At this station, the hard shell moulds are removed

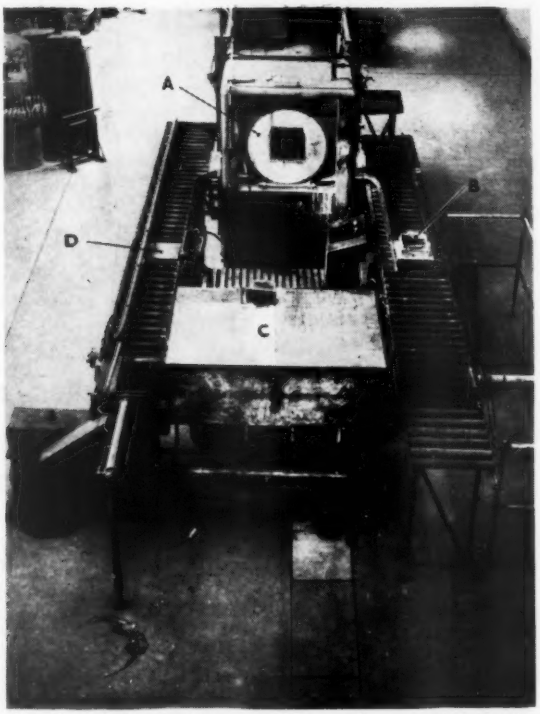


Fig. 4. Shell moulding machine. A—spraying booth; B—sand investment station; C—curing oven; D—ejector station.

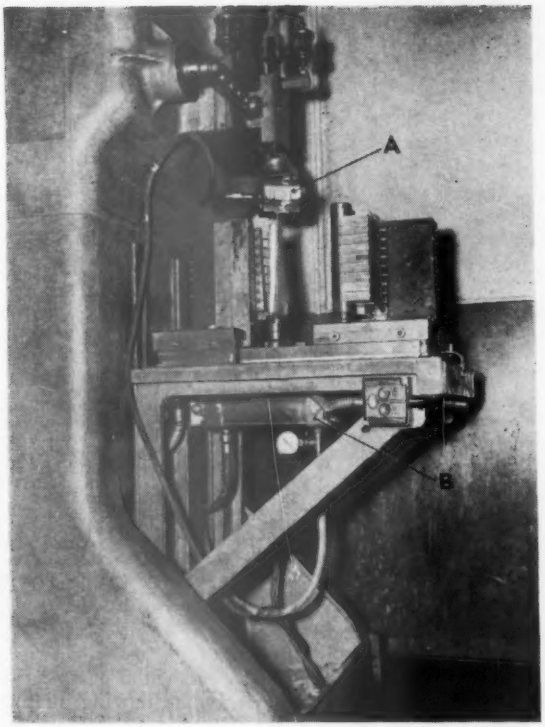


Fig. 5. Polishing machine for gas turbine blade aerofoil sections. A—air chuck; B—air cylinder.

from the master mould by plunger ejectors in the mould; these project below a recess in the base and are raised by an air operated stripper plate built in the roller track. This form of air operated ejection is also used on our large shell moulding machine to eject moulds of an approximate area of 3 ft. × 2 ft. The shells are finally paired and riveted together by an air operated riveting machine and the shell moulds are taken to the furnaces for casting.

Although the employment of air operated equipment in the polishing shop is well known and does not need further mention, I would like to describe a unique machine for polishing the aerofoil sections of compressor and turbine blades which has been developed by my Company. The blade root is held in an air operated chuck (A in Fig. 5) which is moved with a relatively fast, vertical, reciprocating motion, combined with a slow crosswise movement. Meanwhile, the blade aerofoil section is gripped between the felt pads of the polishing fixture, one half of which is fixed, the other half being controlled by an air cylinder, " B " in the illustration.

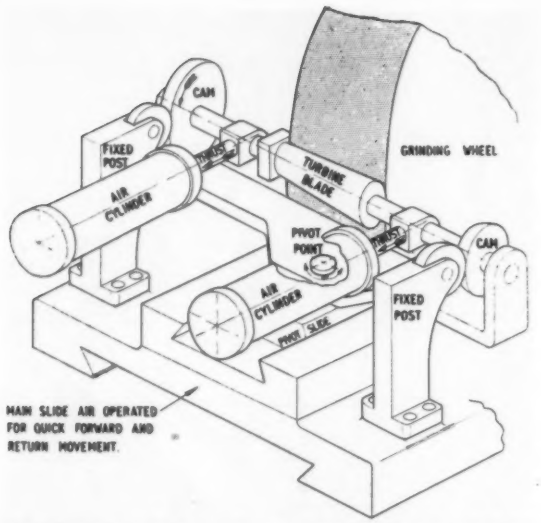
The operator loads the blade into the air chuck and presses the dual switches which energise the solenoid-controlled air valve and operates the air cylinder under the machine table, moving the front half of the fixture up to the blade. When this has completed its travel, it trips a micro-switch which starts the motor driving the reciprocating mechanism. The polishing time is controlled by a pre-set Venner time switch which stops the electric motor and returns the front half of the fixture to its original position, thus completing the fully automatic cycle.

The Blade Forging Shop

Another interesting application is found in our blade forging shop, where several 1,000 ton Hasenclever forging presses are installed. These use air to operate the clutch controlling the hammer movement. Of normal design, these presses have a vertical screw to operate the hammer, at the top of which is attached a large flywheel mounted between two other flywheels secured to a horizontal shaft. The shaft can be moved backwards or forwards to transmit the drive to either side of the flywheel attached to the vertical screw, the movement being controlled in the fully automatic cycle by a solenoid-controlled air valve and cylinder.

Passing on to applications in the main machine shops, we have time only to mention those of special interest. Fig. 6 is a diagram of a Lidkoping centreless grinding machine, adapted by the removal of the control wheel head and the substitution of a pneumatic cam-operated profile generating attachment for grinding blade profiles of straight line fairing design.

The problem here was to produce the rotary and oscillating motion necessary to grind the blade profile. In this connection, air cylinders were adopted



DIAGRAMMATIC SETUP OF THE GENERATING ATTACHMENT FOR GRINDING CONVEX TURBINE BLADE FORM ON THE LIDKOPING CENTRELESS GRINDER SHOWING THE PRINCIPLE OF OPERATION.

Fig. 6.

to maintain the cam-operated work-holder in constant contact with the cam follower while moving on the pivot point of the fixture. The table slide which carries the work holding fixture was arranged for rapid retraction, by an air cylinder, a sufficient distance to enable loading and unloading of the component to be effected without stopping the grinding wheel. The complete grinding cycle including the operation of fixture and slides is fully automatic.

The face turning of rotor and turbine discs was one of the many new machining problems introduced by the inception of the gas turbine engine. These discs have irregular face contours and are suitable components for machining on the Monarch Air

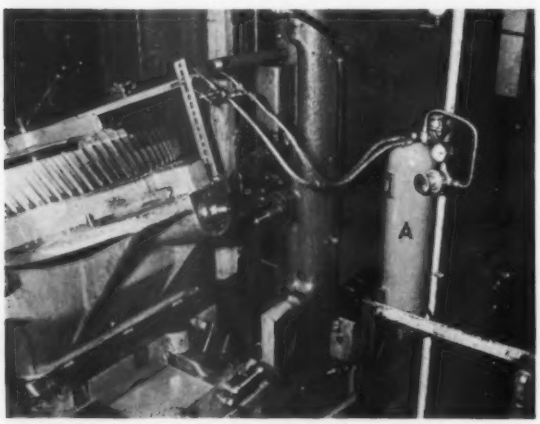


Fig. 8. Compressor air adaptation for spraying cutting oil on broaches. A—pressurised container.

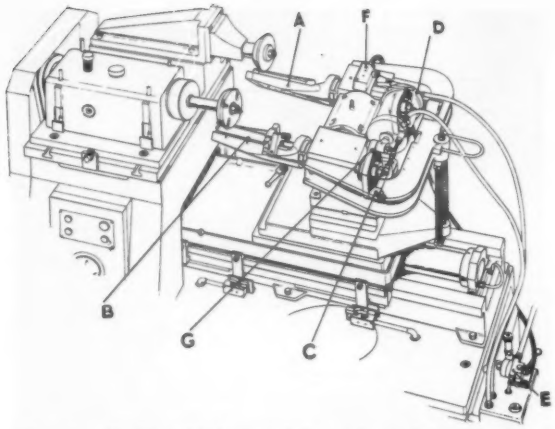


Fig. 7. Turbine blade aerofoil section milling machine. A—master former; B—work holding fixture; C—connecting link; D—air cylinder; E—control valve; F—micro switch; G—double throw crank.

Tracing Tee Bed Lathes, a battery of which my Company installed some time ago and which have proved invaluable. The tool slide of the lathe is hydraulically operated but control is effected by the deflection of a stylus on contact with a former, permitting a release of compressed air, the resulting pressure drop servo actuating the hydraulic mechanism.

Another Machine Tool Application

Another machine tool application is that for milling the aerofoil section of blades, a diagram of which is given in Fig. 7. Here a fabricated base houses the electric motor and hydraulic equipment and also mounts a bridge casting carrying a high speed cutting head and a follower of the same diameter as the cutter.

A slide at the opposite end of the machine mounts a horizontal swivel yoke carrying the master former

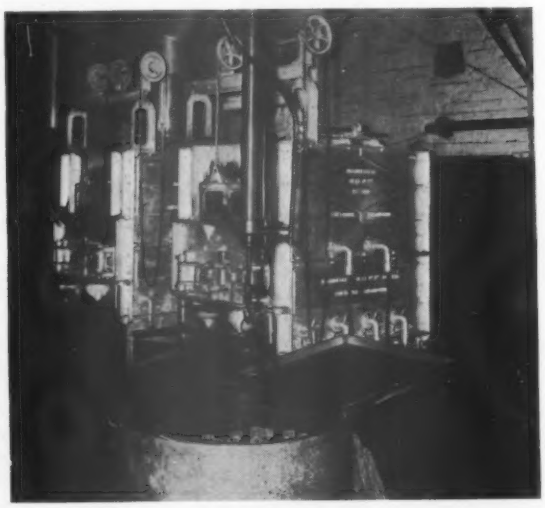


Fig. 9. Pneumatic hoist used when oil quenching.

and work holding fixture, these being maintained in contact with the cutter and follower by two tension springs. Both former and work-holding fixture are connected together by a link attached to a double throw crank connected to an air cylinder. The air cylinder causes the former and work-holding fixture to oscillate automatically under the cutter and follower, the length of oscillation being controlled by a micro-switch operating a solenoid control valve. Air is used in this application because its reaction is quicker than hydraulics. We have also adopted compressed air to spraying cutting oil on the broaches of broaching machines as shown in Fig. 8. Redundant aircraft oxygen cylinders (approximately 6 in. dia. × 18 in. long) are filled with special cutting oil and pressurised at approximately 20 p.s.i. from the shop airline, through a reducing valve. Twin pipes from the bottom of the tank connect with jet nozzles having an orifice diameter of approximately 0.007 in. through which the cutting oil is sprayed on the two sides of the broach, taps in the pipe lines enabling the supply to be turned off when the machine is not working. One filling constitutes a day's supply.

Yet another application is the Bristol "Squeeze Riveting" machine for connecting rod bushes. It must be appreciated that the finish of these bushes is extremely important; consequently they are diamond bored and mechanically burnished. Each bush has two rivets and therefore for each engine large numbers are involved. Our problem was that the impact riveting used before the introduction of this machine sometimes resulted in split rivets and damaged bushes. Initial tests on squeeze riveting have shown that it is essential to rivet in two stages, i.e. an initial squeeze to swell the rivet and fill the rivet hole and a final squeeze to form the rivet head with a recuperative pause between the two squeezes, the time cycle being three seconds for each squeeze and for the intermediate recuperative pause. The following load figures are imposed during riveting operations :-

Hercules Piston Engine Master and Articulated Rods

An initial squeeze of 0.7 tons at a pressure of 15½ p.s.i.

A final squeeze of 1.4 tons at a pressure of 31 p.s.i.

Centaurus Piston Engine Master and Articulated Rods

An initial squeeze of 1.4 tons at a pressure of 31 p.s.i.

A final squeeze of 2.8 tons at a pressure of 62 p.s.i.

The riveting head, powered by a pneumatic ram, has a mechanical advantage of 4 - 1, the air supply to the ram being controlled by a cam operated valve system with reducing valves, thereby providing accurate control of pressure and timing. Mechanically operated valves are used in the design of this machine because the 15 p.s.i. air pressure is considered insufficient to operate the valves accurately. The machine is designed to work off the main line pressure of 65 p.s.i., but subsequent models will have a greater mechanical advantage to allow working at a lower line pressure.

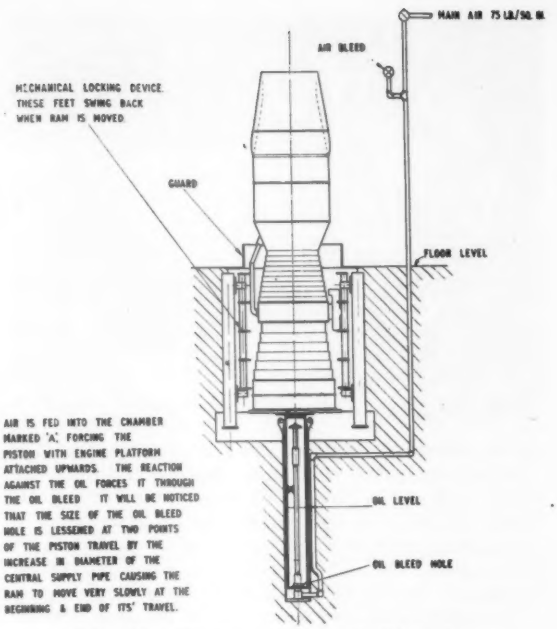

MAIN AIR 75 LB/SQ IN
AIR BLEED
MECHANICAL LOCKING DEVICE. THESE FEET SWING BACK WHEN RAM IS MOVED
GUARD
FLOOR LEVEL
AIR IS FED INTO THE CHAMBER MARKED 'A' FORCING THE PISTON WITH ENGINE PLATFORM ATTACHED UPWARDS. THE REACTION AGAINST THE OIL FORCES IT THROUGH THE OIL BLEED IT WILL BE NOTICED THAT THE SIZE OF THE OIL BLEED HOLE IS LESSENED AT TWO POINTS OF THE PISTON TRAVEL BY THE INCREASE IN DIAMETER OF THE CENTRAL SUPPLY PIPE CAUSING THE RAM TO MOVE VERY SLOWLY AT THE BEGINNING & END OF ITS' TRAVEL.
OIL LEVEL
OIL BLEED HOLE

Fig. 10. Diagram of engine build station.

Various simple examples of applying compressive air to fixture damping can be cited. A typical example is that employed on a single-station shuttle type milling fixture for milling blade root forms in correct relationship to aerofoil blade form. The fixture is basically a pneumatic vice with a platform and end stops on which the shuttle is placed. A pneumatic cylinder beneath the platform operates a shuttle holding toggle clamp and an "on/off" air valve ensures rapid shuttle change.

The air servo "float" for index figures illustrates a different application. In cases where indexing fixtures of large proportions are necessary and where elaboration is precluded due to reasons of economy (often dictated by production quantities) it is usual for heavy index plates to be revolved manually. However, fatigue may be reduced to the minimum in such cases and at least expense, by "floating" the index plate on a compressed air "cushion". This is done by providing an annular recess in the under face of the index plate, having a surface area sufficient for the air to exert a total pressure loading slightly in excess of the weight of the index plate.

The air is usually supplied direct from the shop air line through passages in the index base.

A further application in use by the Company is that of proprietary air chucks which are fitted to a number of capstan and combination turret lathes. Pneumatically operated hand tools are in extensive use for drilling, grinding, rotary filing and hammering. On the inspection side use is made of the Solex air gauge tracer system for the checking of piston engine cylinder bores.

In operation, compressed air is fed through fixed jet orifices in the gauging head which is placed in

the bore to be measured, the resultant pressure drop in the feed line being dependent on the gap between the gauging head and the component bore. A manometer tube records this pressure drop which being proportional to the air gap is also a measurement, many times magnified, of the variation of the bore from nominal size.

The Pneumatic Hoist

Yet another simple, but effective, application I will mention is the pneumatic hoist used in the oil quenching tank employed subsequent to the heat treatment of high tensile steels. This is shown in Fig. 9. The hoist comprises a long-stroke double acting air cylinder and is suspended vertically from an overhead runner. The load is slung from a hook at the lower end, and the whole equipment is then moved over an oil tank sunk into the shop floor. It is, of course, a metallurgical requirement that the load is quenched by continuous dipping and therefore the air cylinder is fitted with an automatic trip gear, which enables the load to be raised and lowered to a distance predetermined by the stops provided for the purpose. An air flow regulator is also embodied to regulate the speed of raising and lowering.

Compressed air also plays a small but very important part in the process of electro-plating. An unwelcome feature in the process is the formation of air bubbles on the plate deposit during build-up, which, if ignored, would produce cavities, etc. and unevenness. To eliminate and/or dislodge these bubbles, it is necessary to agitate the component or the plating solution and it is obviously more convenient to agitate the solution. Compressed air is, therefore, introduced *via* a reducing valve into the bottom of the plating vat and through perforated lead pipes arranged to ensure even agitation.

It is noteworthy that agitation by this method does not affect the rate of deposition.

Cleanliness of components is of the utmost importance in an aero-engine assembly shop; wash tanks are, therefore, fairly numerous. Usually, a jet of air at 75 p.s.i. is directed on the components after washing. However, to eliminate paraffin mist in the shop and objectionable noise, a closed tank has been designed. This has an air-driven turntable and a gallery of jets directed at the components. Paraffin is first sprayed through the jets followed by air at 75 p.s.i. whilst the turntable revolves. This, in effect, washes and dries the component and the fitting of an exhaust duct completes a good job.

We now pass on to yet another application shown in Fig. 10, i.e. pneumatic and hydraulic engine assembly rams. Turbine engines are conveniently built in a vertical position, being much longer than their piston predecessors: in fact, one of our engines is about 14 ft. overall and weighs about 3,800 lb.

The previous building procedure was a line system where the engine passed a series of stations, each being equipped with staging of the required height. To accommodate the final building operation, however, staging 10 ft. high would be required and this is considered unsatisfactory. Consequently, the engine is built on a ram fitted in a deep recess in the shop

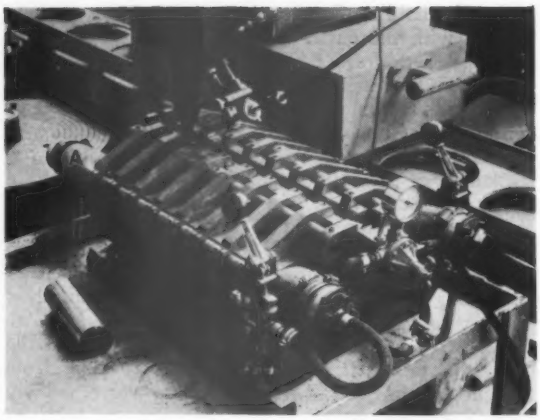


Fig. 11. Air clamping system on welding fixture. A—flexible air hose.

floor, the ram being at the bottom of its travel when the top of the engine is at an easy working height, with the operator standing at floor level. All other positions for building or dismantling the engine can be obtained by adjusting the height of the ram, the operator working always at floor level at natural height. A mechanical locking device is introduced at intervals of approximately 2 ft. so that the engine support attached to the head of the ram comes to rest on the device, and is independent of air leakage. The ram is air-operated, oil-controlled and is of the type widely used in garages.

" Canning " Engines for Transit

An illustration of the diversity of compressed air application is " canning " engines for transit. Obviously, special precautions against corrosion, etc. are necessary and the following system was adopted from the United States and Canada. The engine container is first hermetically sealed, then air at 5 p.s.i. is supplied to the container *via* drying plant. It is claimed that these cans can be lowered overboard and floated ashore without damage during an amphibious operation and that in an experiment with 25 engines stored in the open for two years, all were found to be in perfect condition. Since my Company never seem to have enough workshop space despite continual expansion, we have found it a definite asset to be able to leave these cans outside in the open. The dry air for this purpose is supplied by a Birlec Lectrodryer with a slider vane blower capable of supplying 21 c.f.m. The absorbing agent is activated alumina, which is capable of repeated absorption and re-activation cycles without deterioration of moisture capacity or absorbing efficiency.

Cocooning is another method of preparing engines for transit, and air is employed to spray the cocoon plastics on a webbing surrounding an engine or machine, to form the envelope.

Reverting for a moment to the subject of spraying, the system is so well known that description is unnecessary, but I may mention that we use this system for applying all normal finishing materials. Our

compressed air circuit also supplies the power medium for sand and shot blasting and for the vapour blast. With regard to the vapour blast, it may be of interest to state that the system consists of directing an abrasive water mixture from a spray gun on to a component, such as steel turbine or compressor blades, thereby producing a surface finish and, incidentally, improving the fatigue properties of the material. In addition to employing air to operate the gun, the abrasive mixture is agitated by compressed air to maintain its consistency.

Prunus blasting is yet another application, the blasting medium in this case being the fine grit produced by grinding plum fruit stones after first heat-treating them. This system is employed to remove the carbon from pistons and cylinder heads.

In the assembly shop, as in the machine shop, pneumatically operated hand tools are used to great advantage. Each assembly station has its own pneumatic nut and stud runner attached to an overhead counterpoised fixing and thus readily available for operation.

An interesting application is that of a pneumatic hand riveter with pilot attached, successfully being used as a hammer for the removal of crankcase bolts after extended engine service. The normal extractor was always breaking and the use of drift and hammer damaged the reamed bolt holes.

I would refer briefly to the use of air in salvaging porous light alloy components by impregnation. The castings are placed in a steel chamber and the air is extracted by a pump operated from the shop airline until the occluded air is exhausted from the defective areas. Impregnating solution is then introduced to the chamber until the castings are immersed, but leaving a vacuum at the top of the chamber.

A pressure of 40 p.s.i. is now applied from the shop air line and after a period, the chamber is drained, the castings cleaned and subsequently stoved.

I will now pass on to a few applications at our Rodney Factory. An example is the Clearing crankless 250 ton hydraulic press. On this machine we use an hydro-pneumatic blank holder with a pressure up to 150 tons and the pneumatic die cushion can be

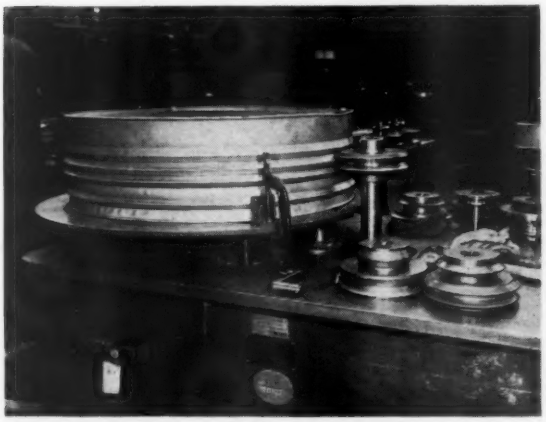


Fig. 13. Bellows rolling machine.

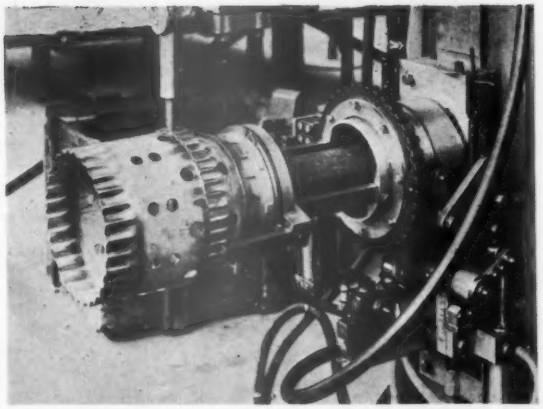


Fig. 12. Air operated index fixture for welding machine.

used to give a triple action, an inside-out draw to the work, or used as a work ejector. Both air applications are supplied direct from the shop air supply at 80 to 90 p.s.i.

Use of Air in Welding

Welding for aero-engine sheet metal fabrications is now an exact science and compressed air is used for three main purposes in this connection. Firstly, to give the very critical pressures to the electrodes during the resistance weld, secondly, for clamping the work and, lastly, for indexing the work to give the correct spacing for each weld. Resistance welding covers spot welding, tack welding, stitch welding and seam welding and the example of electrode pressure I am going to quote is applied to seam welding which is, in fact, continuous or overlapped spot welding. The materials are brought together by a pair of motor driven roller electrodes under pressure, and whilst the materials are passing through them, a series of high-current pulsations are applied, resulting in a continuous weld seam. Three pressures are exerted for each spot weld, first a high clamping pressure, secondly a lower pressure during which the current passes and lastly, a higher forging pressure.

Since the air pressures are extremely critical, a reducing valve and air operated pressure switch, together with a recording type pressure gauge, maintain the pressures within very close limits. One of the welding roller electrodes applies pressure to the work by an air operated diaphragm head which enables rapid reciprocation of the roller during the welding cycle.

Effective clamping of the work, especially for butt welding, is absolutely essential and the following illustration shows how the work is held continuously along both sides of the join by clamps operated by air cylinders. A machine was designed for straight longitudinal seams 10 ft. long and from 8 in. to 16 in. dia., using a Standard Lincoln Electric submerged arc-welding head on a travelling carriage. A very ingenious method of operating the clamps is shown in Fig. 11; here the lever is actuated by inflating a

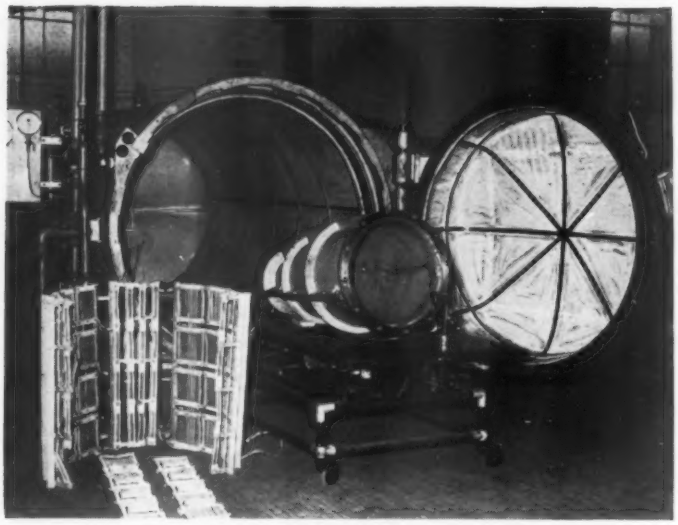


Fig. 14. Small "Autoclave" for metal to metal bonding for airframe components.

canvas hose from the main airline at 80 to 90 p.s.i. The movement is rapid and even pressure is assured on each clamp. After butt welding on this type of machine, the component joint is passed through the weld crushing machine, also designed to remove the slight depression caused in welding. The weld passes between two rollers, the lower being contoured and the upper flat. Pressure is applied to the upper roller by a double-acting air cylinder *via* toggle lever mechanism.

Work Index Attachments

Various air-operated work index attachments are in use, a typical one, illustrated in Fig. 12, being used for stitchwelding flutes on flame tubes. The attachment moves the component forward, providing a stitchweld of 16 welds to the inch. When one flute is stitchwelded, the device automatically indexes the component to the next flute and welds this flute in the opposite direction. Interrupted only when the attachment is indexing, the reverse direction welding continues until the component is completed.

For countersunk riveting on sheet metal too thin to be cut-countersunk, a spin dimpling machine and subsidiary equipment was developed. Briefly, this is similar to a drilling machine but fitted with a special spinning head. The bottom die immediately beneath the head is raised pneumatically, applying controlled pressure between the work piece and the spinning tool. There is little or no inter-rivet distortion of the sheet.

Whilst on the subject of riveting, I may mention that the air for hand tools used when inserting and spreading Chobert blind riveting type of rivets is supplied from the shop airline through an intensifier. One of the problems facing designers using turbine engines buried in the wing is allowing for expansion or contraction of the tail pipe; on delta winged aircraft, this pipe is sometimes about 15 ft. long. This was overcome by introducing a bellows as an integral part of the pipe. The bellows grooves are formed by a machine developed for this purpose and shown in Fig. 13. Two motor-driven vertical mandrels carry the two groove formers. The feed of one mandrel is hand operated, the other being pressed towards the former by means of an air cylinder operating through toggle lever mechanism giving a pressure of approximately 15 tons.

Air Conditioning and Pressurising

I will now pass on to various applications taken from our Aircraft Division, the first of which is the Britannia aircraft air conditioning and pressurising. In modern aircraft, compressed air serves three purposes, i.e. to provide an acceptable pressure in the cabin at altitude, to maintain the desired temperature in the cabin over a wide range of ambient temperatures, and to supply the fresh air for passengers' comfort.

Turbine-engined aircraft have a convenient source of air supply for these purposes in the engine compressor. Air bled from one of the compressor stages is ducted through a flow controller designed to deliver the required amount (about 1 lb. of air per minute per passenger is a reasonable figure). It then passes through a cross-flow heat exchanger in which ram air is used as the coolant. Further cooling is obtained by passing it through a turbine, where heat is absorbed by driving a fan and distributed through the cabin. The pressure in the cabin is normally maintained at an equivalent of 6,000 ft. altitude when the aircraft is flying at 30,000 ft. The cabin pressure and its rate of change are governed by a pressure controller, which controls discharge valves through which the air in the cabin returns to the atmosphere.

Temperature control is effected thermostatically. The required temperature is selected on a dial and temperature sensitive elements control electronically the proportion of air passing through the complete cooling system to the air which by-passes all or part of the system. When the aircraft is on the ground

under tropical conditions and the main engines are shut down, it is still necessary to provide the air-conditioning services described above, though actual pressurisation would be for test purposes only. In addition to heating and cooling, fumigation and deodorisation may be required. The power plant of the air conditioning trolley designed to perform these ground services is a petrol engine coupled to a Godfrey M.2000 compressor of the positive displacement Roots type, which supplies the air at a rate of up to 1,860 c.f.m. with temperatures from ambient to 120°F. A temperature drop of 90°F. is available.

Heated air is obtained by tapping air direct from the compressor, the heat generated by normal compression being increased by raising the back pressure on the compressor by means of a throttling orifice plate. The heating capacity is 300,000 B.Th.Us/hr. minimum.

The induction of deodorant or fumigant (anti-pest) into the charge air may take place during heating or cooling as required, and at a rate dependent on conditions.

Finally, for ground test pressurisation at 8.7 p.s.i., air is passed through the primary heat exchanger only, to reduce its temperature, the rate of supply being 1,250 c.f.m. So much for Britannia air-conditioning.

Vacuum and Pneumatic Clamping

Let us now consider vacuum and pneumatic clamping applied to bonding processes. Air pressure is employed as the clamping medium in the fabrication of various aircraft sections involving the bonding together of both wood and metal components.

In the former case, large wooden panels are pressed together (after the introduction of the bonding agent) by atmospheric pressure, the equipment being known as a "Vacuum Fabricated Panel Glueing Bench". This is simply a large wooden table, its top surface being covered with a blanket of thin rubber sheet. The panels are placed between table and blanket and the latter is then clamped down around its perimeter. A partial vacuum is then created between table top and blanket by using a Speedivac single-stage high vacuum pump. The blanket moulds itself around the panel assembly applying a pressure of up to 13 p.s.i.

The evacuated rubber bag method of clamping is also used in the process of metal to metal bonding of non-stressed airframe components, such as stiffener ribs for panels. The component parts, after first applying the bonding agent to the surfaces, being joined, are placed in a holding fixture which is then clamped under the rubber blanket.

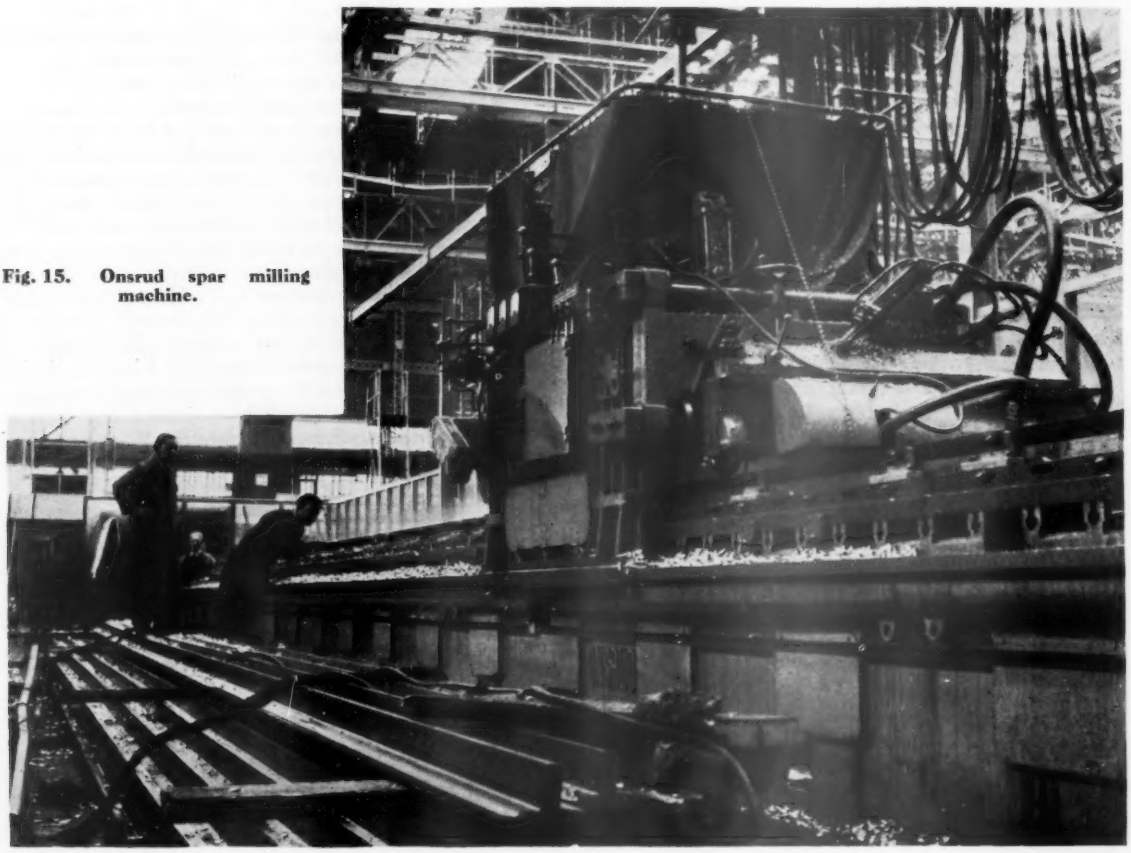


Fig. 15. Onsrud spar milling machine.

Since the bonding agent used in this process requires the application of higher pressures than atmospheric at the joint surfaces, it is also necessary to heat the assembly. Both these requirements are met by placing the complete assembly in a pressurised oven, heated either by steam or electric elements. The autoclave shown in Fig. 14 is capable of being pressurised to 80 - 100 p.s.i., charge air being drawn from a storage vessel supplied from the factory service line. Storage avoids excessive loading on the system over a short period of time. As recharging only takes place at intervals of about 80 mins. there is ample time to replenish the reservoir from service compressors. Actual pressures used in the autoclave depend, of course, upon the requirements of the bonding process and is additional to that created by the vacuum blanket. In practice, the vacuum line may be opened to atmosphere provided the rubber blanket clamping is absolutely leakproof. Service line air is also used on this circuit for operating the thermostatically controlled diaphragm valve for regulating the steam supply.

Applications to Machining

Now for one or two applications from the machining side of the Aircraft Division. The two Onsrud spar milling machines shown in Fig. 15 have recently been installed for the purpose of contour milling sections of the Britannia mainspar. The machine is designed with a fixed bed which may be extended as required, and four independent work spindles (two vertical and two horizontal) are mounted on a carriage which traverses the length of the bed. The contour following movement of the work heads is attained by the contact of a roller follower with a template attached to the workholding fixtures on the machine bed. The roller follower is held in contact by pneumatic pressure, this being derived from a 5 in. bore double acting air cylinder of the usual pattern. Line pressure of 100 p.s.i. supplied to the machine is boosted to 700 p.s.i. for cylinder operation.

Travel of the cutting head assembly is limited by a template, since movement stops when the roller follower makes contact. A further air cylinder beneath the head applies a constant upward force equal to the weight of the assembly. This acts as a counterbalance and makes possible the high rates of feed of which the machine is capable (up to 200 inches per minute) since the cutter head can change position quickly, even for very abrupt changes in direction.

The work-holding fixtures on these machines are also air operated, and are built up in 6 ft. unit lengths. Some units have four pairs of pull down clamps, each clamp hook having a direct pull from a 3 in. bore double acting cylinder supplied from the service line at 100 p.s.i.; four pusher or vice clamps are also spaced along each unit; these too are actuated by a 3 in. bore cylinder.

Safety arrangements :-

In the event of air supply failure, the carriage head and spindle motors are switched off automatically; the cutout is adjustable and is normally set to permit a drop of 5 p.s.i. in the line pressure. Air pressure to the work-holding clamps is maintained for a short period by using a non-return valve in the supply line.

Vacuum chucks present another interesting application. It has been found necessary, for certain special applications, to machine the surfaces of thin metal sheets to produce very fine tapers and obviously the clamping of sheets measuring about 8 ft. × 3 ft. presents some difficulty. This problem has been overcome by using a vacuum chuck on the table, thus making use of atmospheric air pressure to hold the sheet. The sheet is sealed by a rubber ring around the perimeter of the chuck and the air is drawn off by a single stage high vacuum pump through holes in the top surface.

A further application is found in the helicopter clutch running-in rig. This test rig is used for running in and setting the Weller multi plate clutch used for transmitting the main rotor drive on our helicopters. It is actuated pneumatically in the following manner. A double acting air cylinder supplied from the service line through a reducing valve is arranged to reciprocate automatically, this motion being transmitted through a chain drive to a three-toothed pawl and ratchet. The ratchet shaft is splined to mate with the clutch drive, the driven flange of the clutch being held stationary on a three-spigot location.

Through this arrangement, an intermittent rotary motion may be imparted to the clutch. To give a smooth snatch-free action, a hydraulic damper is coupled to the other side of the chain drive. Variation in the operating speed is attained through a regulating valve on this damper. The variable air pressure to the operating cylinder gives a torque value as required for limiting adjustments on the clutch.

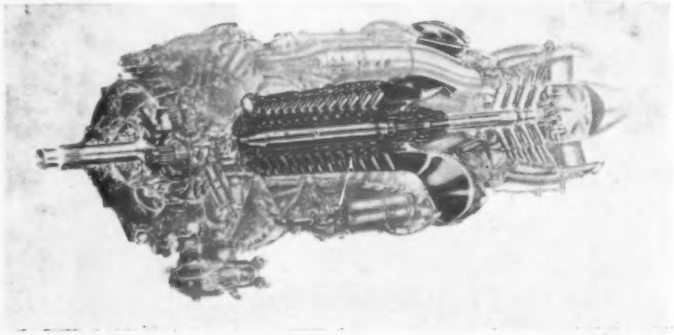


Fig. 16. Bristol Proteus gas turbine compressor.

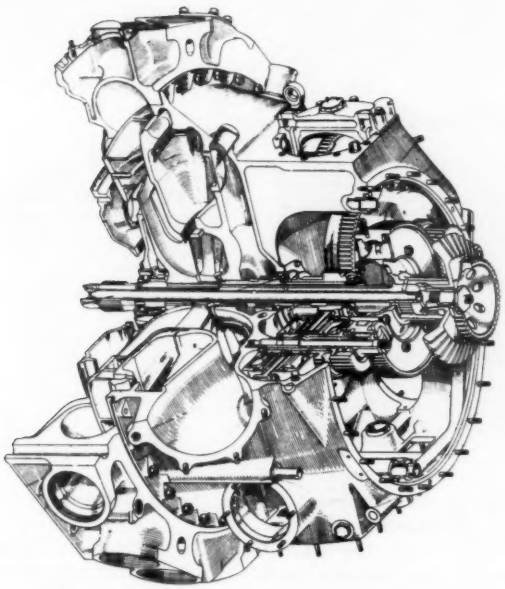


Fig. 17. Bristol Centaurus supercharger.

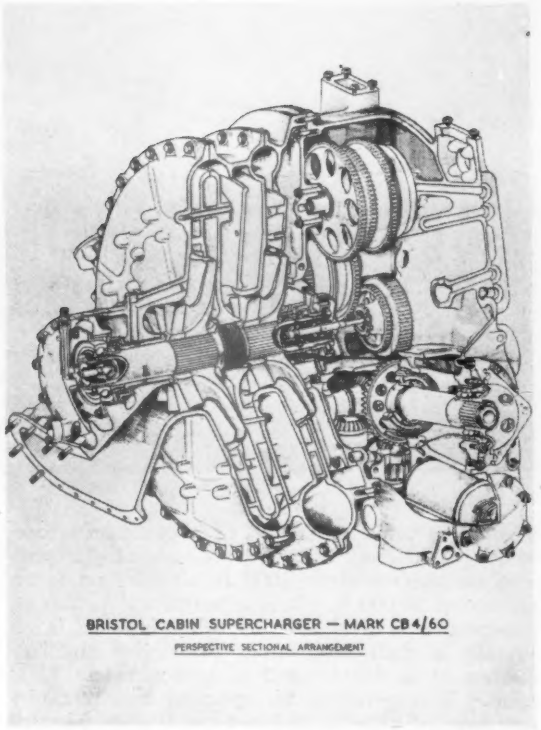


Fig. 18. Bristol cabin blower.

Manufactured Products using Air for their Performance

The subject of this Conference is " Compressed Air as an Aid to Improved Productivity ", but I feel that a brief description of a few of our products designed to produce compressed air in large quantities will be of interest to you. These are of interest constructionally and also in the comparison of their performance and output with their commercial counterparts.

Later in this lecture I shall be discussing our air requirements for test and research departments, where vast quantities of compressed air are consumed, the quantity calibrations of which can only be measured in pounds per second. Such " mass flows " are not easily obtainable and since compressors of the desired specification and output could not be obtained from commercial sources, we have been obliged to use compressors of our own design and manufacture for supplying our requirements; slave gas-turbine compressors for the larger mass flows and piston engine blowers and cabin blowers for medium quantity flows.

A Proteus axial-flow compressor such as we use for service purposes is shown in Fig. 16, which gives some idea of its constructional features. The particular compressors used are those of one of our earlier marks of engines and produces a mass flow output of 44 lb. per second at 75 p.s.i. (gauge) absorbing 5,000 h.p. at 10,000 r.p.m. The delivery velocity is in the order of 400 ft. per sec. and the output temperature approximately 245°C. The compressor is 26 in. long with a smaller bore of 16 in. diameter and the large bore 18¾ in. diameter. At 10,000 r.p.m. the blade tip speed is approximately 900 ft. per sec.

Let us compare its output against that of one of the largest commercial compressors installed at our Works. The compressor I have in mind is a double-acting two stage compressor with intercooling between stages and at 410 r.p.m. delivers 650 cubic feet of air per minute at 90 p.s.i. The driving motor is 135 b.h.p. and the mass flow would be approximately 0.82 lb. per sec. To obtain an equivalent mass flow to that of the Proteus compressor giving 44 lb. per sec. we should require 54 of these compressor units.

I think you will admit that the very small and compact Proteus unit is extremely efficient for its size.

Another aero-engine unit employed to supply large quantities of air to individual component research rigs is the two-speed supercharger shown in Fig. 17. This was designed as an integral part of a Centaurus piston aero-engine. It is small, compact and light for its output and being built to operate under varying altitude conditions, it has two-speed clutch units which drive the impellor at 16,000 or 21,600 r.p.m., the horsepower absorbed being approximately 300 under flight conditions. At the higher speed normally used for " take off ", the blower delivers a mass flow of approximately 5.3 lb. per sec. and at the lower or flight cruising speed approximately 3.3 lb. per sec. Referring to Fig. 17, the impellor is 13¾ in. diameter, which gives a good indication of the size of the unit. Used as a slave blower, its output can be varied dependent on the horsepower and driving speeds available.

The cabin blower shown in Fig. 18 was designed

Fig. 19. Bristol compressor turbine research station.

to supply a minimum of 1 lb. of fresh air per second while maintaining a cabin pressure of 11 p.s.i. absolute (equivalent to 8,000 ft. altitude) up to an altitude of 39,000 ft. It is a centrifugal two-stage, two-speed type of blower and, when installed in an aircraft, is shaft-driven from the engine auxiliary gearbox at an input speed of approximately 3,800 r.p.m. The two-speed oil operated clutch enables two ratios of impellor to input speed to be selected. Thus, at the lower ratio, the impellor speed is approximately 15,700 r.p.m. and at the higher ratio 20,500 r.p.m. When used as a slave blower, its output can be varied dependent on the horsepower and driving speeds available.

Use of Compressed Air in the Research Departments

Ever since the advent of the gas turbine aero-engine, the industry has been faced with the problem of producing compressed air in large quantities for research and test. One of the basic components of this engine is the compressor, which supplies compressed air to the combustion chambers; these deliver it at extremely high velocity to the turbines. Consequently, a considerable amount of research work must be carried out on components such as blades and blade rotor wheels, etc. in addition to complete units. To facilitate these tests, the Bristol company built the compressor and turbine research station shown

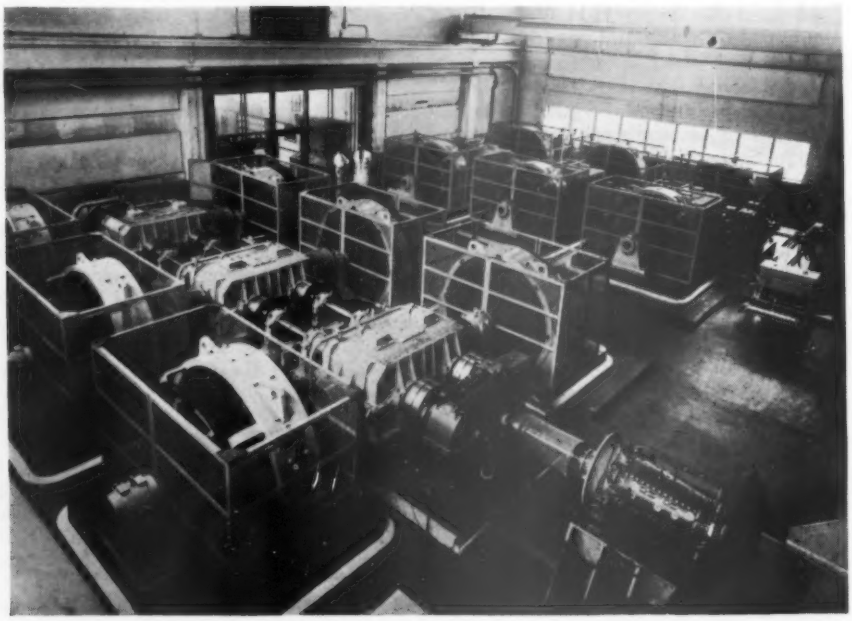


Fig. 20. Main hall of compressor and turbine research station.

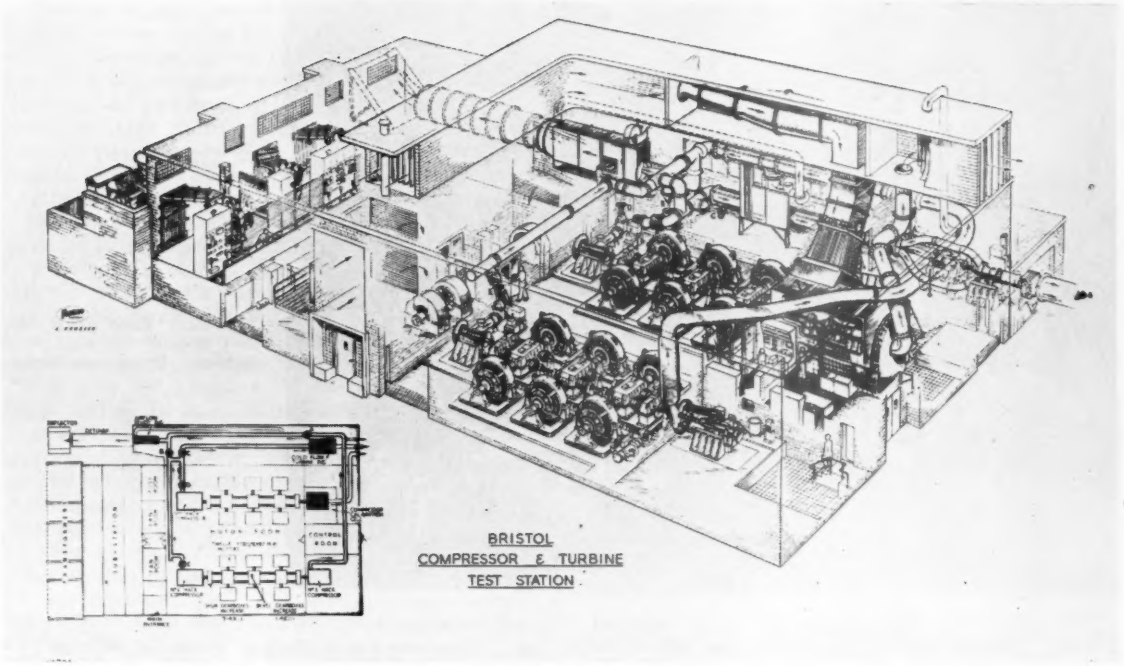


Fig. 21.

in Fig. 19; this is known affectionately as the "Gin Palace".

As originally envisaged, the layout of the station enabled gas turbine compressors to be calibrated separately, or in conjunction with the appropriate turbine. The compressor was to be driven by electric motors and the mass flow from the compressor ducted through combustion chambers to a turbine which would drive generators to supply the compressor driving motors. Thus the plant was largely to be self-sustaining on a regenerative basis. Operation of the station was begun with two compressor driving motors and two turbine-driven generators. Subsequently, a second pair were added to each strand and finally a third pair. It soon became apparent, however, that a basic rearrangement of function was necessary. The link-up between compressor and turbine limited the station's utility and, in any event, the value of turbine assessment was questionable because of the extreme difficulty of obtaining accurate measurements of small temperature changes at the high gas temperatures involved. The turbine was, therefore, replaced by a Proteus slave compressor and a cold air flow rig was installed in an annexe for turbine test and calibration. Subsequently, two more slave compressors were installed to increase the mass flow still further, making up the layout shown in Figs. 20 and 21; this is the set-up to-day.

These three compressors are capable of producing a mass flow of 126 lb. per sec. and this is available for the cold flow turbine rig, a high speed air flow study rig, a supersonic wind tunnel, or for delivery to adjacent combustion research cells. Compressor calibration work is carried out in a separate test cell.

The twelve electric D.C. motors which drive the compressors have a continuous rating of 1,750 h.p. each at 900 r.p.m. and a maximum of 2,190 h.p. at 972 r.p.m., the maximum being available for two-hourly periods. They are fed from 16 mercury-arc rectifiers of 19,600 kW capacity, which in turn are fed from five tap changing transformers of 18,200 kVa total output, receiving their supply from the 11,000 volt grid system. The motors are capable of infinitely-variable speeds achieved by a combination of rectifier, grid control, tap changing transformer and a motor field control.

As I have already mentioned, the station was built originally for compressor and turbine research, and the initial increase in air mass flow requirements was due to the change-over to cold flow turbine testing. Cold flow testing enables mild steel rotor discs and light alloy blades to be used, thus reducing the interval between designing and testing a new blade form. This method, i.e. using relatively cold air, eliminates the use of expensive alloy steels and reduces appreciably the time taken to manufacture a set of turbine blades and, as previously described, the lower temperatures enable the performance characteristics to be more readily determined.

During the test, pressures at the various points are indicated by manometer tubes (using coloured water for the low pressure and mercury for the higher pressures), and the load being absorbed by the dynamometer is registered on a brake-type weighing machine.

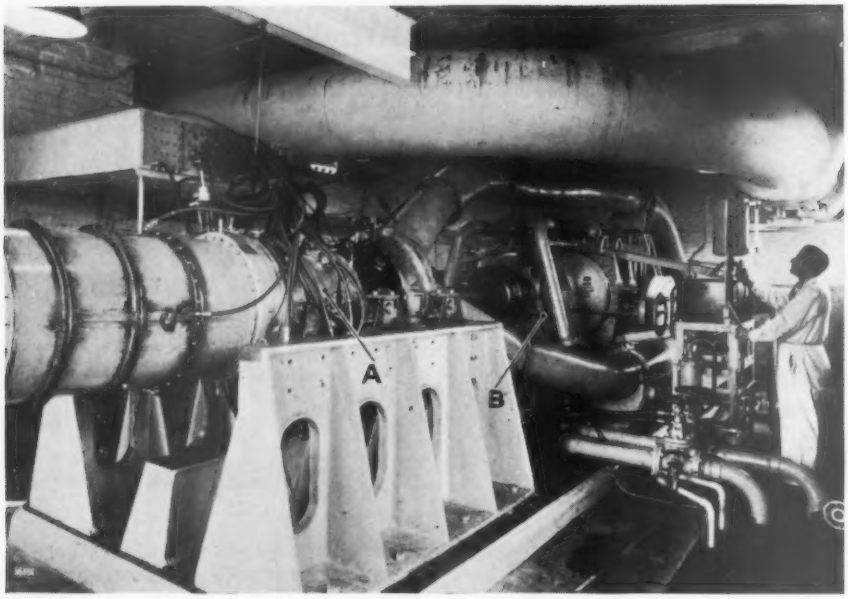


Fig. 22. High speed cold flow turbine test rig. A—turbine; B—dynamometer.

The exhaust air from the rig cannot be released directly to atmosphere, as to do so would be both noisy and dangerous due to the high velocity of the outgoing air. Consequently, it has been necessary to provide adequate silencing and dispersal equipment.

The building shown in the foreground of Fig. 23 is situated at the rear of the compressor and turbine test station, and was constructed to fulfil these requirements. It houses expansion chambers, cascade diffusers and noise splitters, the outlet to atmosphere being situated in the roof. The whole unit, including the brick and concrete structure, is in suspension and is joined to the main building by one inch thick padding of expandable plastic material. This allows for elongation expansion due to exhaust air temperature changes.

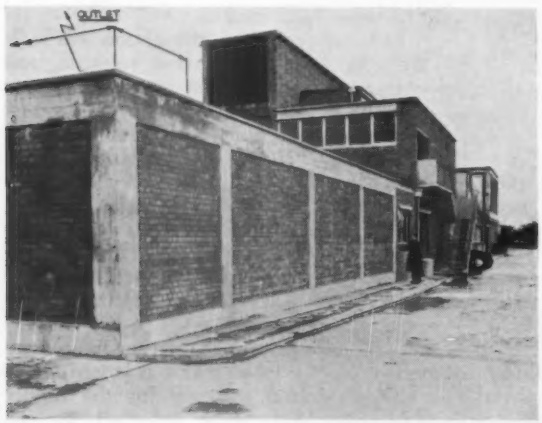


Fig. 23. Rear view of compressor and turbine research station.

A second rig requiring a high mass flow is the air flow study rig, also situated in the test station annexe. This is designed to check air flow over blade aerofoil sections and to carry out calibration tests on other components of a similar nature, using air at supersonic speeds supplied by the slave compressors. The speed and flow of the air is governed by a convergent/divergent nozzle which is designed to suit the particular application.

The axial flow compressor, as is well known, is very critical to surge conditions, and in order to protect the compressors we have installed a number of emergency dump valves in the main ducting in the roof of the station. These valves, some of which are fully automatic and some manually operated by remote control from the control room, can release the compressed air direct to atmosphere in the event of excess pressure building up, sufficient to induce surging.

Supply of air to individual rigs is effected by means of 14 in. diameter hand operated valves, one of which can be seen in Fig. 24, illustrating the lagged ducting through which the air is fed.

The air supplied by the slave compressors is not confined to the test station research rigs, but is also ducted underground to adjacent test houses and rigs requiring large mass flows. Typical of these rigs is the high speed combustion chamber rig shown in Fig. 25 on which full size combustion units for our jet engines are calibrated and tested. Inlet mass flow requirements are very high; for instance, one particular test on a combustion unit consumes air at the rate of 80 lb. per second at a pressure of 65 p.s.i., the air being ducted through a two foot diameter pipe at 60 feet per second to a British Standard flow orifice, not shown in the illustration. An orifice for measuring flow is built into the inlet ducting of any rig requiring large quantities of compressed air.

The air is then passed to a sluice valve which restricts the main mass flow, the greater part passing through the valve and the remainder through by-pass pipes to small preheating combustion chambers which heat the air and pass it back to the main stream from the sluice valve. The velocity of air at this point is approximately 80 ft. per second and its temperature 240°C. It is then fed into the combustion unit being calibrated.

Referring to Fig. 25, expansion units marked "E" cater for longitudinal expansion in the long inlet pipe.

At the rear end of the cell a trumpet shaped diffuser receives the exhaust gases. Immediately forward of the diffuser throat, water is sprayed into the hot exhaust gases and mixing of entrained air, water and gases takes place on the passage through the diffuser, thus cooling the effluent. At the rear trunk end of the annulus is a diffuser basket, which is a fabricated steel cone. This cone is housed in a large expansion chamber and further assists to break up and deflect the gas flow, distributing it throughout the silencing chamber. The chamber walls are lined with light alloy corrugated sheet, a two inch lagging of fibre glass providing thermal protection to the concrete skin of the building. At the opposite end of the chamber, the gases pass through vertical silencing splitters which are 50 ft. in length. These are arranged as a series of passages approximately 2 ft.

Fig. 24. Main lagged piping for delivering high mass flows. A—main 14" stop valve.

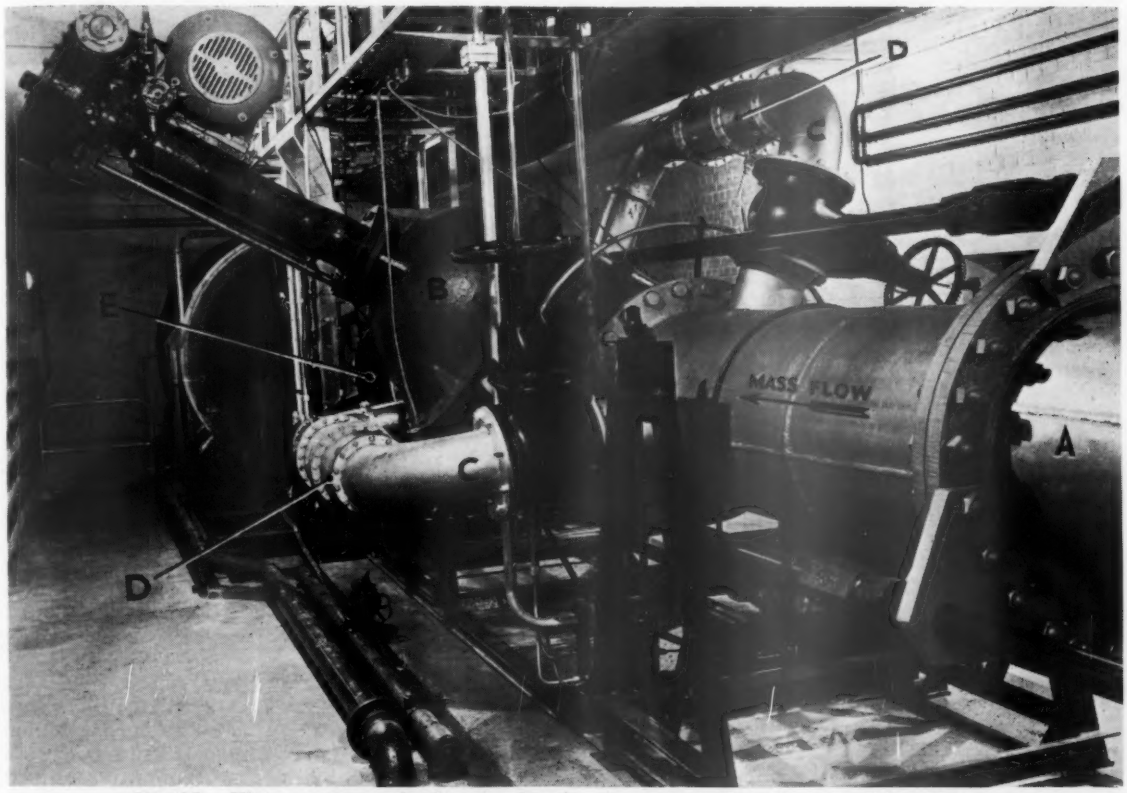


Fig. 25. High pressure combustion chamber rig. A—main ducting; B—main sluice valve; C—by-pass ducting for air heating; D—combustion chamber's heating air; E—expansion unit.

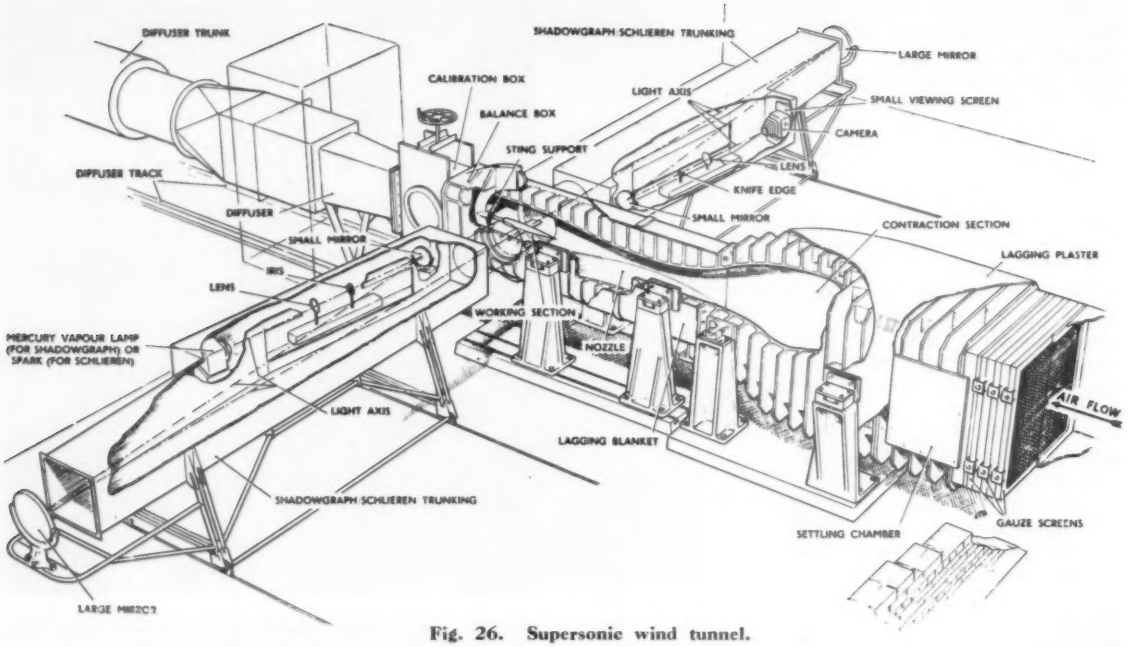


Fig. 26. Supersonic wind tunnel.

apart and laid out in the form of a dog's leg. Here again the splitter walls are built with light alloy perforated sheet covering fibre glass lagging. The gases then pass out to atmosphere. The outlet end of the splitter section faces a bank of rubble built up as an added protection.

The supersonic wind tunnel shown in Fig. 26 also obtains its air from the slave compressors of the turbine test station. It was designed by the Company for air flow study work and is capable of mass flow velocities ranging from mach 1.75 to mach 3.5. The air is passed through heavily lagged piping from a convergent/divergent nozzle and on through the test section to discharge diffusers and silencers and, finally, to atmosphere at comparatively low speeds.

As the air is heated during its compression, the inclusion of air heating and drying installation is unnecessary. This is a great advantage as such an installation would cost more than the actual tunnel.

The research department's constant complaint is that there is not sufficient mass flow for their requirements. The rigs normally supplied with air from the test station compressors are on a strict supply rota and should any rig not be prepared to receive air through a fault or hold-up, at the commencement of their allotted period, they forfeit their turn and may have to wait the complete round of rota.

In order to increase the mass flow still further, we are contemplating replacing the three Proteus II compressors by four compressors of a later and more powerful mark of Proteus engine. These compressors, when installed, will utilise to the full the horsepower available from the existing electrical installation.

To augment the supply we are also installing a multi-stage centrifugal compressor of commercial manufacture specially designed to suit our requirements, followed by the installation of a second compressor of similar design which will increase both the mass flow and output pressure of the first unit.

Individual Compressor Installations

Many research rigs requiring smaller mass air flows have individual compressor installations, the compressor type depending on the rig requirements.

Fig. 27 shows an installation of four Whittaker Hall two-stage water-cooled compressors for supplying air to a single combustion chamber research rig and overspeed test cell. These compressors deliver air to receivers of 260 cubic feet capacity at 70 p.s.i. and at the rate of 1,210 cubic feet per minute. In the combustion chamber rig, air is passed through a combustion chamber at an observed velocity and mass flow equal to a proportional output of the relative engine compressor. Fuel injected into the chamber is ignited with a glow or impulse plug: calibration checks and figures can then be taken. A restricted valve in the exhaust ducting can be adjusted to give the back pressure normally created by the engine turbine.

In the overspeed cell, a turbine rotor under test is rotated at high speed, mild steel blocks of the same mass as the correct blades being secured to its periphery, instead of actual turbine blades which would require greater horsepower to drive and prove more costly to manufacture. Air is passed through the rotor and blocks to simulate engine

conditions. In cases where it is necessary to test actual blades, the air can be evacuated from the cell by the Whittaker Hall Unit to assist the driving motor in attaining the high speeds necessary.

As I have already mentioned, piston engine blowers are also used to supply air to research rigs. For example, the Centaurus 57 blower shown in Fig. 28 is driven by a 600 h.p. motor and delivers a mass flow of 6 to 7 lb./sec. to a general component cascade and flutter test rig. This rig enables flutter in a turbine stator segment to be observed. The segment has a "loose" blade which reacts to the swirl of air through adjacent fixed blades.

The air for the fuel gas analysis rig shown in Fig. 29 is supplied by a slave cabin blower. This is driven by a 600 h.p. motor and delivers a mass flow of 2½ lb. per sec. The analysis rig in the illustration is engaged in calibrating the gas flow in the stator segment throat area. Air is supplied from the blower through pipes to a combustion chamber "B", the exhaust passing through stator segment throat area "A".

Another fuel calibration rig, shown in Fig. 30, obtains its air output from a Sirocco two-stage centrifugal fan, which has an output of 10 lb. per sec. mass flow at 5 p.s.i. and is driven by a 250 h.p. motor. A bypass in the main ducting receives part of the mass flow and passes it through a small pre-heating combustion chamber for heating, before delivering it back into the main stream. In the illustration the combustion unit is marked "B".

Fatigue Testing

A rig developed to simulate flight conditions when fatigue testing multi-stages of compressor rotor units in model or full scale form is shown in Fig. 31. The rotors can be driven at extremely high speed by means of an increase speed box driven by two 600 h.p. coupled motors, one end of the drive shaft being coupled to a Centaurus blower. This is used either to supply compressed air to the output end of the compressor on test, or to help evacuate air from the casing so that considerably less power is required to drive the component. This enables the rotors to be run at high speeds and the elongation of the blades due to centrifugal forces can be plotted until destruction occurs.

Another application of air to material fatigue test for compressor and turbine blades is the blade jet vibration test shown in Fig. 32. The blade under

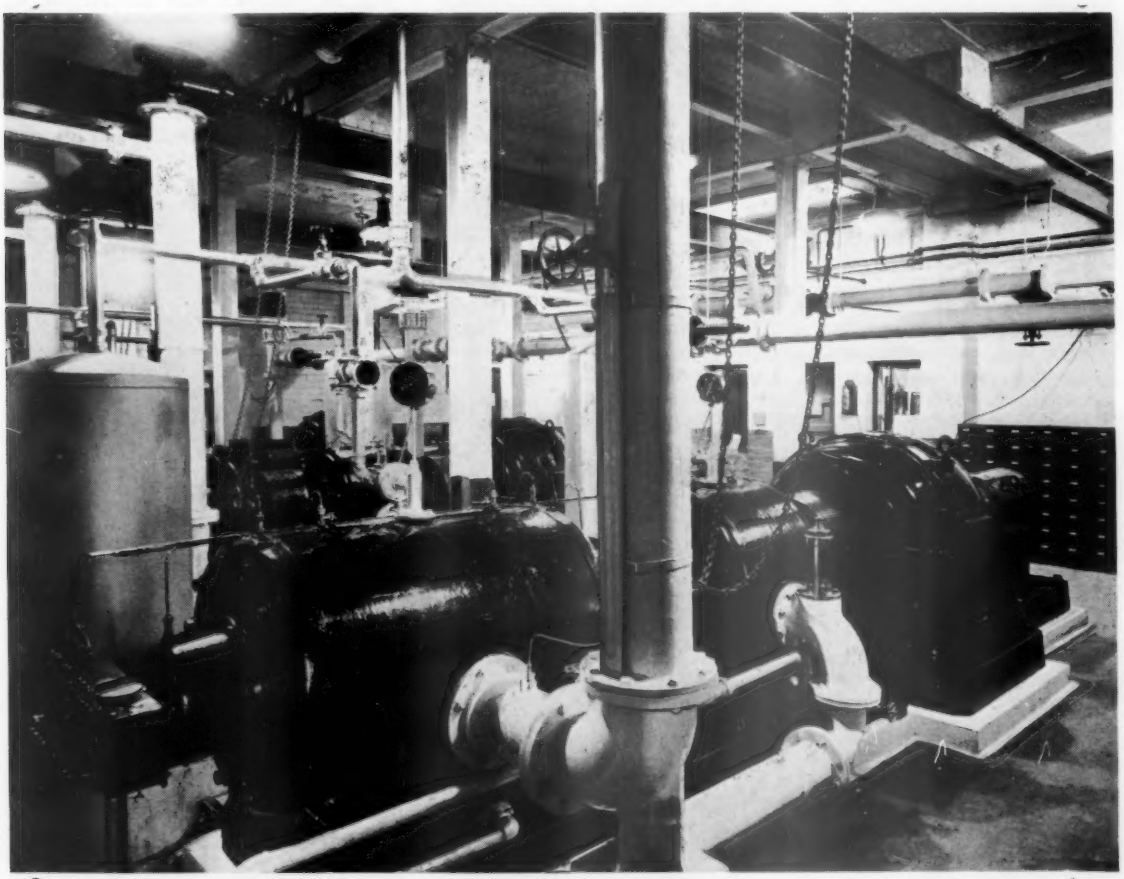


Fig. 27. Whittaker Hall installation.

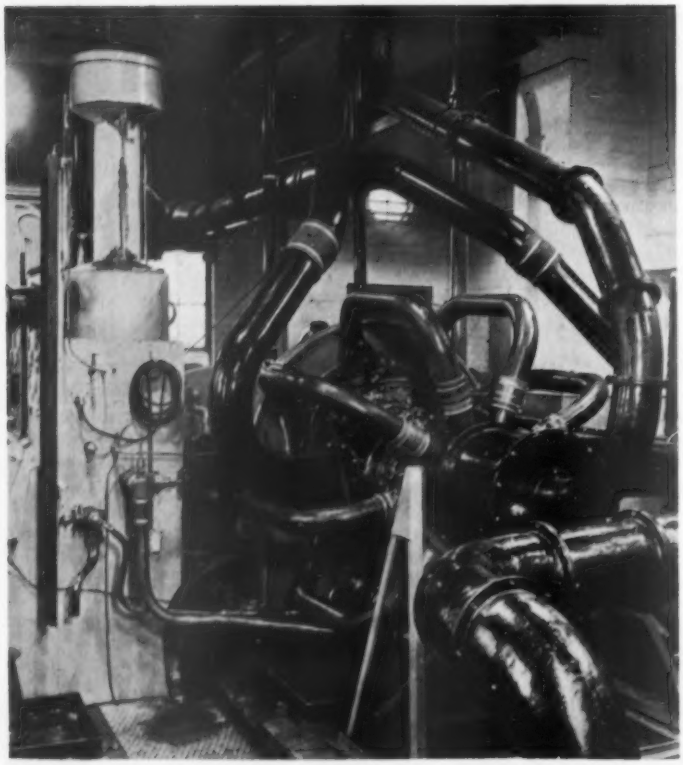


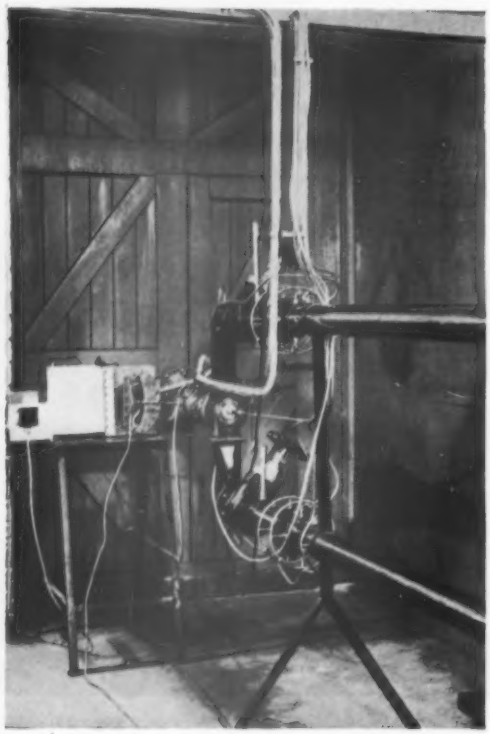
Fig. 28. (*left*) **Centaurus 57 blower installation.**

Fig. 29. (*below*) **Fuel gas analysis rig.**

test is held firmly by its root and a jet of air is directed at it from above or adjacent to its leading edge. An electric pick-up stylus, placed near its surface, records the vibrational frequency with the aid of an oscillograph.

We have covered many test applications concerned with the fatigue performance and the output of the turbine and compressor units, but there is still one interesting application where compressed air is essential, i.e. research into anti-icing of cascades and entry guide vanes. For this purpose, a special rig has been designed to reproduce in the cascade the atmospheric conditions under which icing occurs during flight, that is, with the pressure down to 5 p.s.i. absolute (30,000 ft.), the temperature at minus 30°C. and the water content representative of typical cloud conditions encountered during flight research. Under these conditions, air from the compressor is passed through the hollow vanes, the temperature of the air affected being noted.

You will appreciate that rather elaborate equipment is necessary to produce typical cloud conditions, for the water droplet size must be controlled closely and it is necessary first to dry the air by passing it through activated alumina. Cooling is effected prior to air entering the compressor and again before it enters the turbine. Subsequent to the final cooling, the required amount of water is added through a specially designed spray nozzle, the disposition and size of the water droplets being tested before the air enters the cascade.



Use of Compressed Air in Production Engine Testing

Compressed air is utilised to facilitate starting of one of our smaller types of gas turbine engines.

The air starter unit employed, designed and manufactured by Rotax, Ltd., is a single-stage, high-speed impulse turbine operated by air at 250 p.s.i. from storage bottles (see Fig. 33) pressurised from 2,500 to 3,500 p.s.i. It will accelerate the engine compressor and turbine from start to 2,300 r.p.m. in 5½ seconds using approximately 4½ lb. of air and giving 40 h.p. peak output. The pressure ratio across the turbine is 16 : 1 and requires a mass flow of 0.8 lb. per sec.

It comprises a turbine wheel, compound planetary, reduction gearing, clutch and engaging mechanism as well as an overspeed cut out device. Since it weighs only 19 lb. its power-weight ratio is the highest ever designed for its particular purpose. A comparable electric starter would weigh approximately 55 lb.

The solenoid-actuated pressure control valve is situated near the source of supply and is operated from the test house control cabin. By storing air at 3,500 p.s.i. in special containers, it is possible to obtain approximately 10 starts of 5 seconds duration before exhausting the containers.

The containers are mounted on small trolleys which are convenient for transportation to the test houses or airfield. When empty they are charged by a special high pressure Lacey Hulbert compressor unit, the air being first passed through a carbon filter to remove all foreign matter and then through activated alumina filter to remove all moisture. Fig. 34 illustrates a service platform which has been installed in our Proteus test cell in order to facilitate final adjustment to the engine. Due to the swing of the propellor the platform, when raised, is at a height of about 10 ft. from the floor and must be lowered during engine running. Operation of the platform is effected by compressed air in a similar manner to that described for the engine building stand.

Other applications of compressed air in the test department worthy of mention are :-

1. the ensuring of constant fuel pressure to the engine injector by means of an air operated control valve ;
2. the cooling of thermocouple leads by the use of dry compressed air at 60 p.s.i.

Fig. 30. Fuel Calibration rig.

Conclusions

Reviewing my experience of the use of compressed air in the manufacturing workshops, I am led to the

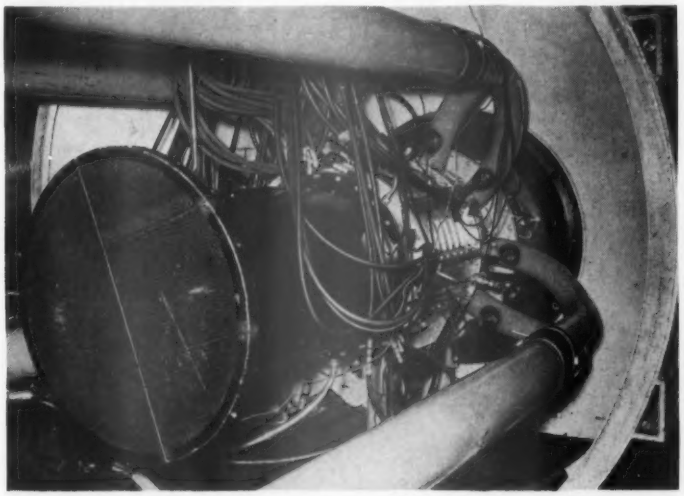


Fig. 31.
Fatigue testing for compressor rotor units.

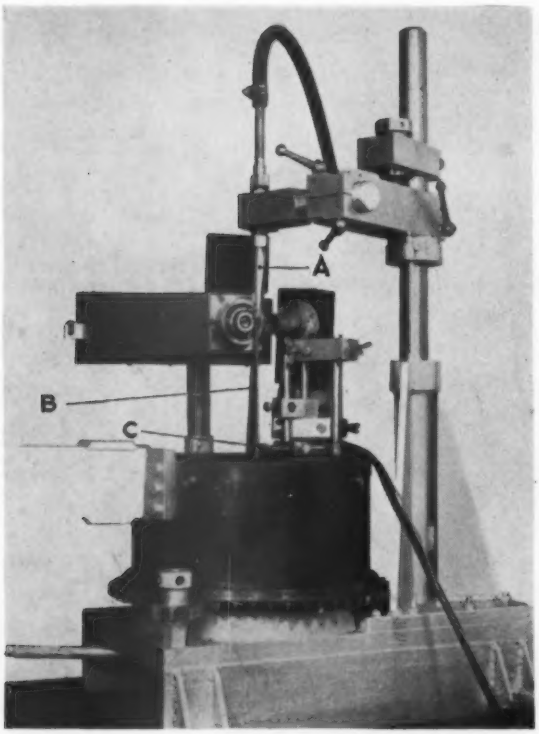


Fig. 32. Blade vibration test rig. A—air nozzle; B—blade under test; C—pick-up stylus.

conclusion that one of the major advantages of air as a power medium is its simplicity, adaptability and extreme flexibility. These desirable features are reflected in the system of control available to the user, and based on the use of a variety of standard items of equipment made up in series or combinations which can be readily adapted to many applications. I have found that speed of operation is a further great advantage especially where automatic control is required, the velocity of air being many times that of hydraulic fluids. Another advantage is its reliability at abnormal temperatures; fluid transmissions require cooling and heating systems to maintain even fluid temperature for constant feed control, whereas air will meter at almost constant rate in freezing outdoor conditions.

On the debit side I consider that one of the major disadvantages of air for certain applications is its compressibility, which makes it unsuitable for constant-precision feeds under varying loads.

Another serious disadvantage which I am constantly encountering is the resulting drop in pressure in the airline due to intermittent loads, particularly at peak periods in the day when demand is at its heaviest; consequently, if an application is installed requiring a steady pressure, it is necessary to come down to an input pressure less than the minimum fluctuations, involving the installing at extra cost of pressure reducing equipment.

Referring to the question of compressor installations in the manufacturing shops, it has been my experience that the plant offered commercially is both efficient and very reliable and leaves little to be desired. Compressed air equipment in standardised forms for use in the manufacturing shops is readily available and the manufacturers are to be congratulated in providing such useful varieties of accessories of an excellent quality.

On the research side we have seen in this Paper that the introduction of the gas turbine engine has brought in its train an overwhelming demand for compressed air in quantities previously undreamed of. Suitable commercial compressors capable of achieving the desired mass flows were not obtainable; neither was it a practical proposition, for many reasons, to install the phenomenally large quantities of commercial compressors of normal capacity necessary to obtain the desired mass flows.

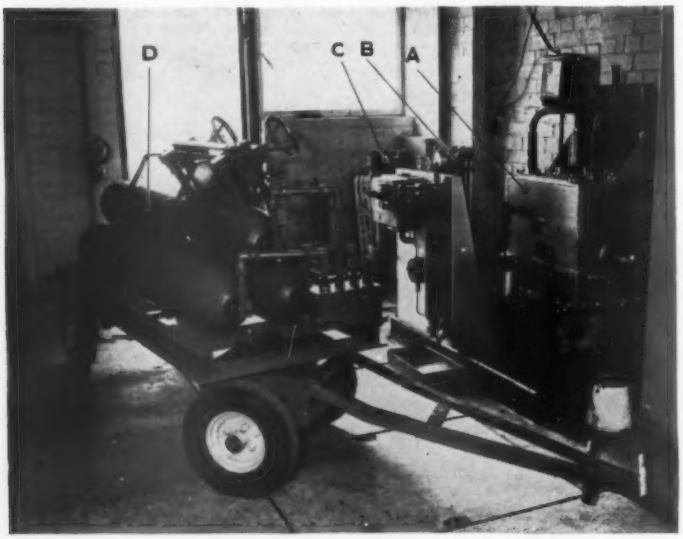


Fig. 33. Compressor and receiver for Rotax air starter. A—water-cooled Lacey-Hulbert compressor; B—carbon filter; C—activated alumina filter; D—air receivers.

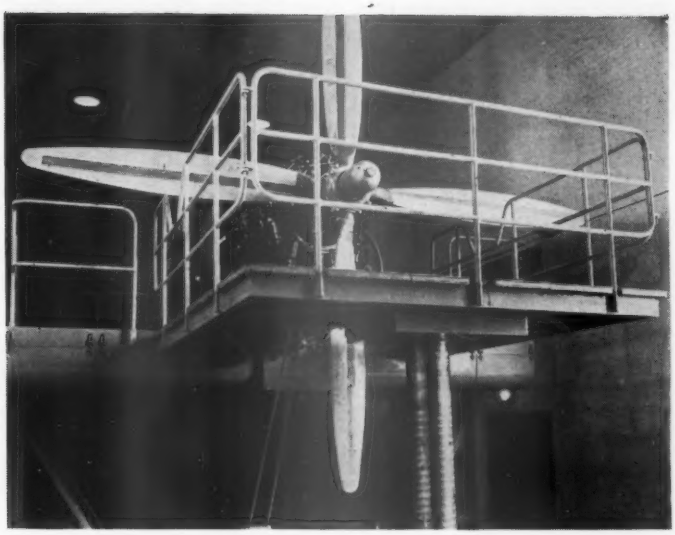


Fig. 34. Service platform for Proteus engine test cell.

We have seen how my Company overcame this problem by installing axial flow compressors of their own design and manufacture for large mass flows, utilising existing buildings and electrical installations as far as possible, and superchargers and cabin blowers for medium mass flows. We do not pretend that our axial flow compressors are the complete answer, since they suffer from such disadvantages as susceptibility to surge inherent in all axial flow compressors and because of aircraft requirements are lighter and more highly stressed than one would expect from their commercial counterpart.

With the advent of the ram jet engine which does not possess its own compressor and relies on external sources of air for its performance, coupled with the further development of the gas turbine engine, the need will be for more and more air. I would, therefore, suggest that the manufacturers of compressor installations could turn with advantage to the development of commercial compressors capable of the large mass flows required by the aircraft industry and possessing the advantage of continuous flow, minimum space requirements, economy of initial and operating costs with the standard of reliability usually associated with commercial compressor installations.

Acknowledgments

Acknowledgments are due to "Flight" and "Aircraft Production" for permission to reproduce the drawings of the compressor and turbine test station (Fig. 21) and the blade aerofoil milling machine (Fig. 7); also to Messrs. Rotax, Ltd., for allowing me to describe their starter unit.

I also wish sincerely to thank my firm, The Bristol Aeroplane Co. Ltd., for allowing me to describe and illustrate some of the many applications involving the use of compressed air in current use in their factories.

Finally, I extend my grateful thanks to those colleagues, who assisted me so ably in the preparation of this Paper, in particular Messrs. K. H. Jenkins, W. E. H. Goodger and D. E. Priday of my Company.

PRODUCTION METHODS IN RAILWAY WORKSHOPS

by T. B. MADDISON, B.E.M.,
A.M.I.Prod.E., M.I.Loco.E.

Presented to the Doncaster Section of the Institution, 12th October, 1954.

Mr. Maddison

Mr. Maddison received his early engineering training at the L.N.E. Railway Locomotive Works at Darlington. After a period with Associated Locomotive Equipment, Ltd., London, on the development of poppet valve gears he returned to Darlington Railway Works to take charge of the Tool Room. Later, he was appointed Chief Machine Shop and Tool Room Foreman.

In 1948, he took up the position of Technical Cost Assistant to the Mechanical Engineer, Darlington, being responsible for the administration of budgetary control of expenditure in the Locomotive and Carriage and Wagon Works of the North Eastern Region.

Subsequently, Mr. Maddison was appointed Production and Works Assistant to the Chief Mechanical and Electrical and Carriage and Wagon Engineers, Eastern and North Eastern Regions of British Railways at Doncaster.

I WOULD like to state at the outset that any difficulties experienced in the preparation of this Paper were not in connection with the material that should be included, but rather what should be left out.

Railway production covers a vast field of commodities, and in the particular Regions with which I am associated, there are 11 main works, employing a staff of approximately 21,000, so you will appreciate it is rather difficult to pick out certain details and at the same time maintain continuity. It would have been comparatively easy to include rows and rows of capstan lathes, milling machines, planing machines, etc., which are no doubt very impressive, but after all these can be found in most large workshops today.

For the benefit of the younger members here tonight and a few of the older ones also, I beg leave to ask you to take note of the theme when reading the Paper as I have endeavoured to blend the higher techniques of production management (about which we hear so much today) with their application at shop floor level where, after all, true production begins and ends. Admittedly, some of these are very brief and are merely referred to, as time will not permit detailed reference.

To quote a few :-

Stores control
Internal transport
Mechanised schedule control
Budgetary control of costs
The historical aspect
Machine development
Relation of design to manufacture

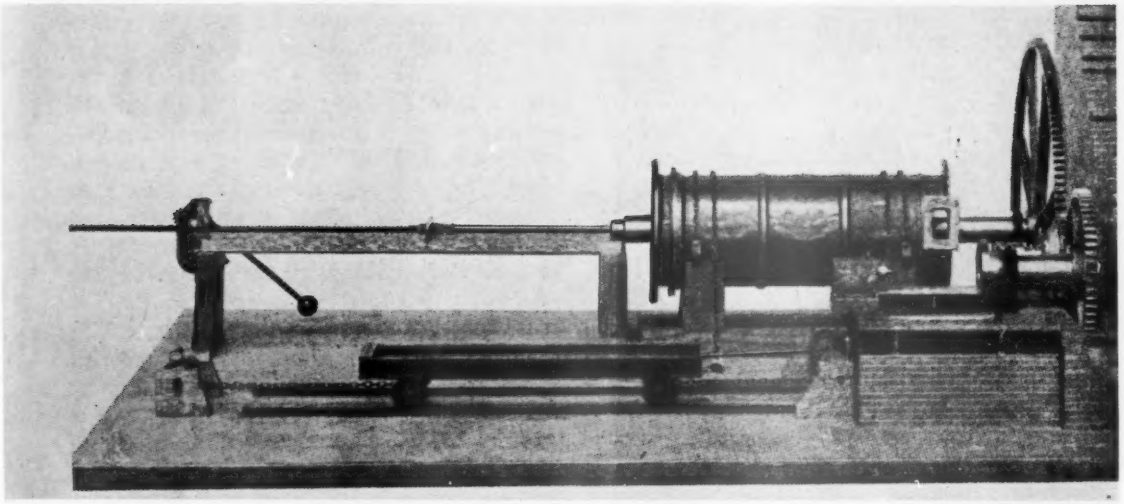


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Fig. 1. Wilkinson's early boring machine (from an exhibit in the Science Museum, South Kensington, London.)

The relation of the foundry to the machine
The application of the theory of hydraulics to overcome production problems
Process planning
Methods study
Machine design in relation to cost

You will agree each one of these could form the subject of a Paper on its own, but I have endeavoured to blend them under the title I have chosen.

The Earliest Days

From the earliest pioneer days, locomotive engineers in this country have endeavoured to extract more and more power from locomotives designed within the limitations of the 4′ 8½″ track gauge and the set width and height of the loading gauge.

Associated with each new design of locomotive, whether it be steam, electric, diesel electric, diesel mechanical or gas turbine, are the inevitable special production problems which are not only present in the original manufacture, but are manifest in the subsequent maintenance and periodical general overhaul of the locomotive. Similar problems are presented in the production and maintenance of carriages and wagons, and you will, therefore, appreciate that in the limited time at my disposal, only a very few of the production methods can be dealt with.

For this reason my remarks will be directed to the steam locomotive side only and these, I trust, will give you some idea of how a few of the more specialised production methods have been developed in one of the British Railways workshops.

The General Picture

Rough material is obtained from our own foundries, forges and from outside contractors, and stocked in the rough material stores compounds. It is drawn from these compounds as required by schedule to the various processing shops, and in the case of the Machine Shop, should marking-off be required, to the marking-off tables, and from that point routed to the various machines, in a pre-planned sequence.

The rough material, semi-finished or completely finished parts are delivered by the petrol or diesel truck system of internal transport which operates in all shops.

As far as possible, machines necessary for progressive machining operations are grouped in order to ensure minimum transportation from one operation to the next.

After the machining has been completed, the components pass either to the finished part stores or to the fitting benches, to be sub-assembled, ready for the Erecting Shop.

A comprehensive system of jigs and special tools is used to ensure interchangeability of detail. The jigs and special tools are all designed and manufactured in our own tool departments.

On all new construction and stock items for repairs, the documentary control of material, process operations and piecework prices is by a mechanised schedule system.

All direct expenditure and overheads other than direct material is controlled by " Budgetary Control " system. Regular monthly reports are issued by the Accountant's Department to keep the Manager and Foremen informed of any departure from the budgeted figures, and meetings are held at both works and headquarters level to investigate variances from budget.

Type of Production

Production as a rule can be divided into three distinct groups :-

1. jobbing production ;
2. batch production ;
3. mass production.

As far as the requirements for the new construction and repair of locomotives are concerned, the majority

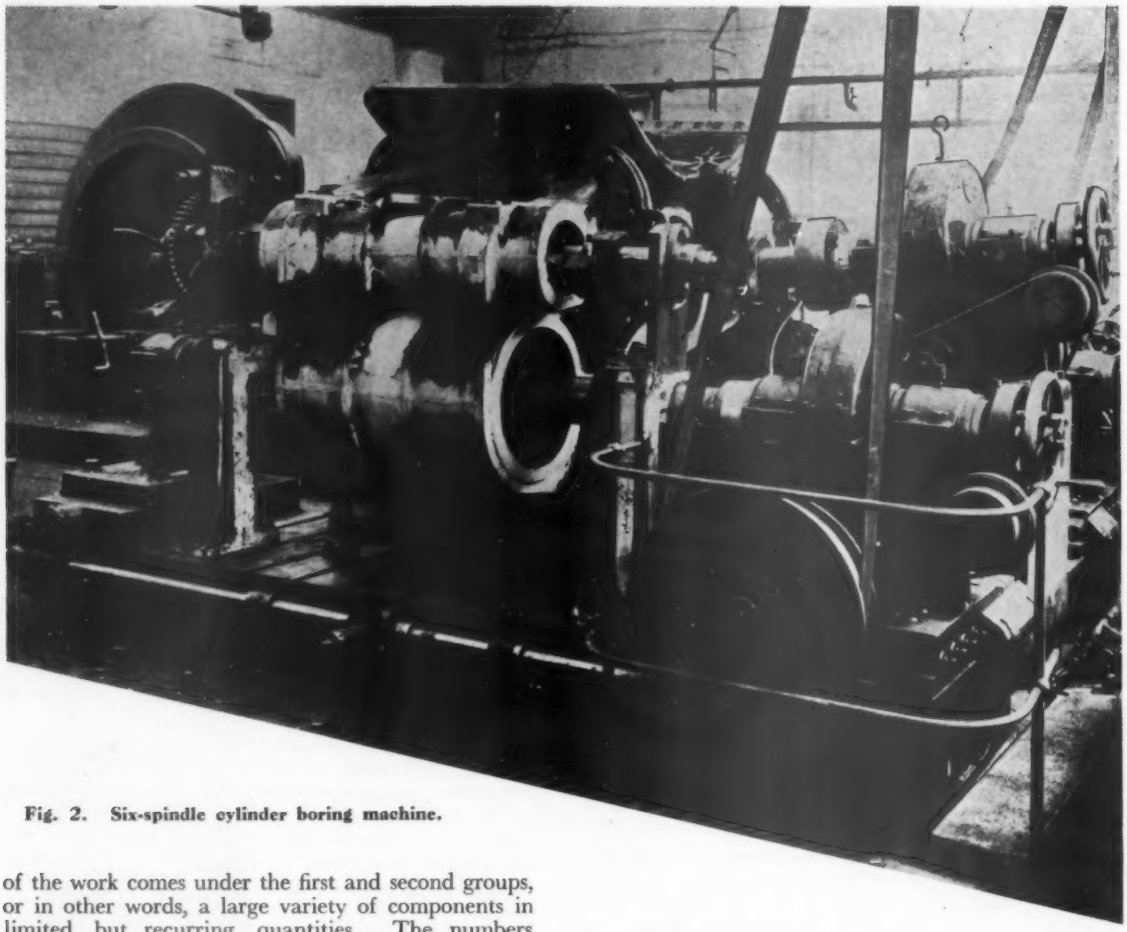


Fig. 2. Six-spindle cylinder boring machine.

of the work comes under the first and second groups, or in other words, a large variety of components in limited, but recurring, quantities. The numbers required *per annum* are not in the majority of cases sufficient to justify special purpose machines of the type used in, say, the motor car industry. It is, therefore, necessary to have as far as possible general purpose machines which can readily be adapted to meet all requirements. This does not imply that special purpose machines are not used in railway workshops, far from it; certain operations to the larger components can only be performed on machines specially constructed for that purpose. In fact, a number of modern general purpose machines owe their birthright to the special or single-purpose machines originally evolved to overcome the machining difficulties experienced by the pioneers of the steam engine and the locomotive, and before proceeding with the various production methods, I think it would prove of interest if we reviewed in retrospect the development of at least one of these machines which, as a general purpose machine, can be found in most medium and large size factories today.

I refer to the horizontal boring and facing machine. The need for this type of machine was undoubtedly brought about by the advent of the steam engine.

Early Boring Mills

In about the year 1724 the first boring mills were introduced by Smeaton, for boring large steam engine cylinders. The boring head, fitted with cutters, was carried on the end of a square bar which was loosely coupled by gearing to the axle of a water wheel, but no outer support was provided for the boring bar.

In 1775, John Wilkinson made similar machines with the rotating bar supported at both ends and carrying a traversing cutter block, which was fed forward by a rod down the centre of the bar (Fig. 1).

These machines were massive in construction, having boring bars 12 inches in diameter by 15 feet long and all James Watt's early steam engine cylinders were bored on this type of machine. It is stated that Watt in his letter to Smeaton said: "Mr. Wilkinson has improved the art of boring cylinders, so that I promise you upon a 72″ cylinder being not further distant from absolute truth than the thickness of a thin sixpence in the worst part."

This, one might say, was the origination of limits and fits.

Fig. 2 shows a six-spindle horizontal boring

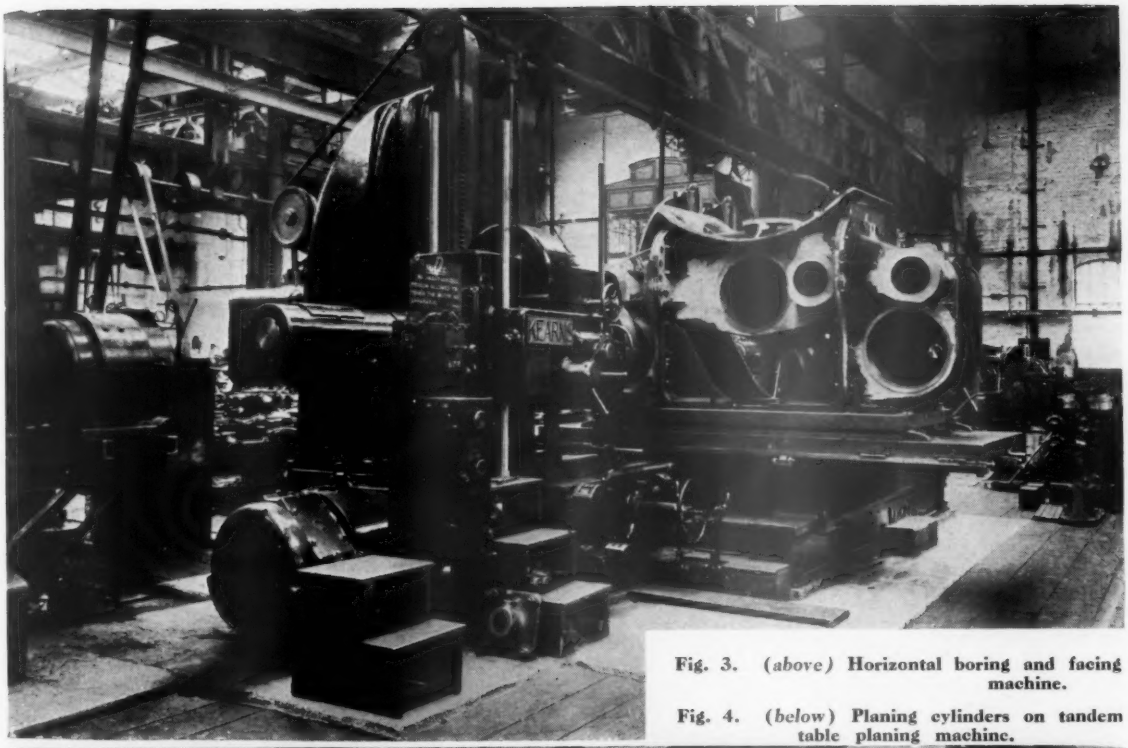


Fig. 3. (*above*) Horizontal boring and facing machine.

Fig. 4. (*below*) Planing cylinders on tandem table planing machine.

machine which operates on the similar principle to the Wilkinson machine and with the development of which the Author was associated 30 years ago. This machine was used for boring triple locomotive cylinders having three 6" boring bars for the cylinder bores and three 3½" diameter boring bars for the piston valve bores. The centres of the boring bars in the horizontal plane were calibrated by verniers; the vertical height of the bars, however, was fixed and the cylinders to be bored had to be set by various jig plates to suit the boring bars.

The advent of carbide tools, together with the disadvantage of having a special set-up for each type of cylinder, made this machine obsolete, and this work is now performed on horizontal boring and facing machines as shown in Fig. 3. This shows a triple cylinder set-up for boring the right-hand barrel on a large boring and facing machine. It will be noted that this machine is fitted with extended side members on the bed, to accommodate the long travel of the table necessary to cater for the wide cylinder centres. The underside edge of the centre cylinder flange is used as a face for location. This edge rests on the two cast iron angle fixtures and this locates the two outside cylinders and the piston valve chambers in a horizontal position ready for facing and boring. The relative centre distances and heights are obtained by vernier scales in 1/1,000 in., these being fitted to both table and head traverses.

The centre cylinder is at an inclination to the other bores and, therefore, requires a further setting before machining.

Cylinders

The design and manufacture of cylinders is one of the principal problems with which the locomotive designer has been confronted. In the early days the limiting factor was the equipment available in the foundry and machine shops, and it was necessary to design the cylinders in comparatively small sections and bolt these together when multi cylinders were required. In the last twenty-five years, however, the development of foundry and machine equipment has been such, that it is no longer the limiting factor.

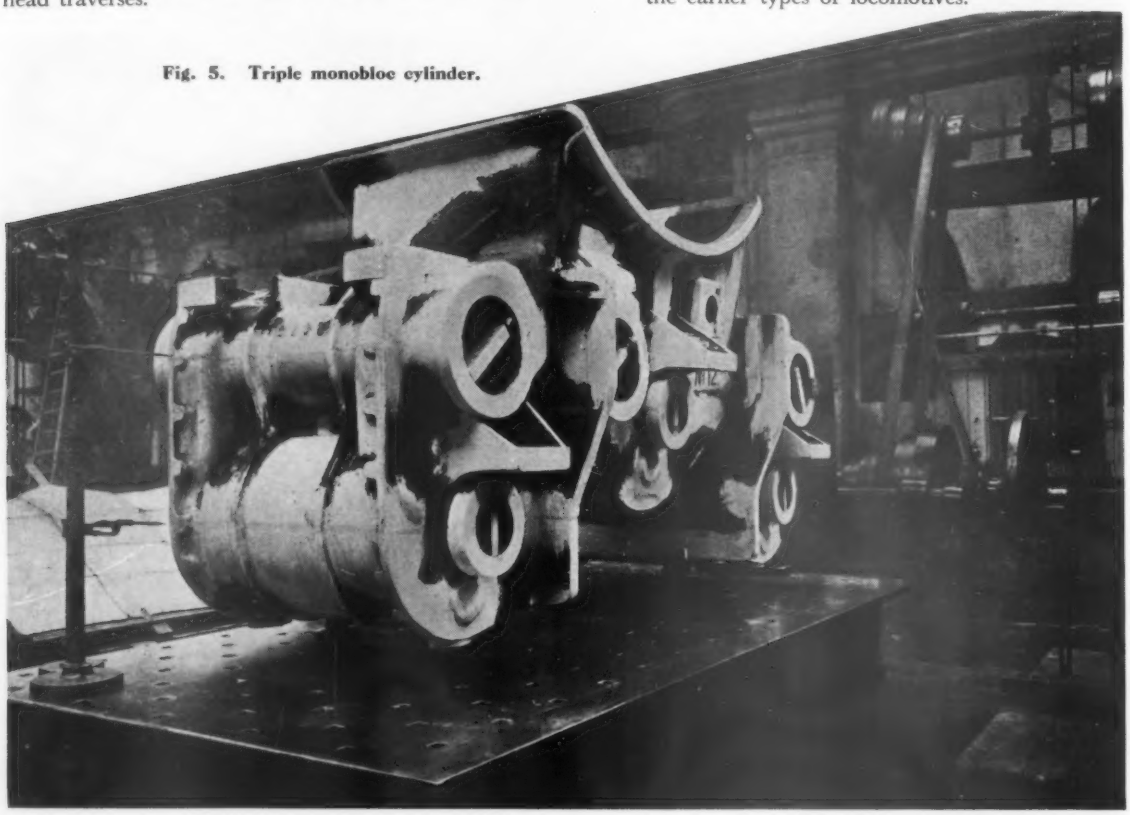
Large numbers of cylinders are required each year for engine repairs, in addition to those necessary for the construction of new locomotives and this justifies having a shop specially equipped for the machining and fitting of these.

I now propose to give you an idea of various types of cylinders now dealt with, which will also let you see the development in the past years.

Types of Cylinders

1. *Twin inside separate cylinders.* These are cast in halves and joined together through the centre line of the valve chest. These are for the earlier types of locomotives.

Fig. 5. Triple monobloc cylinder.



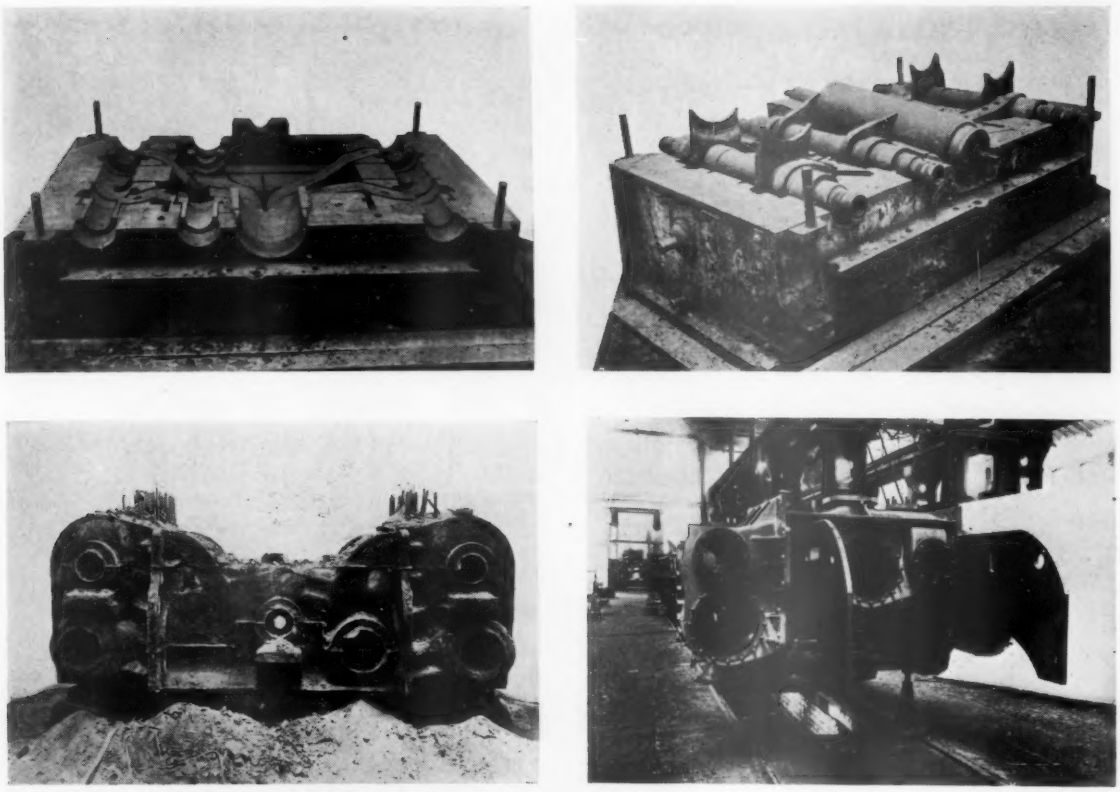


Fig. 6. Four views of progress in construction and building up of mould for triple monobloc cylinder.

2. *Twin inside cylinders.* Both cylinders and valve chests are cast in one.

Fig. 4 shows the joint faces on a pair of twin half-cylinders being machined on a tandem table planing machine. On the idle table is a twin inside cylinder which has just had the frame fits machined; both sides are machined together with the side heads while the seating for the blast pipe is machined with a crossrail head.

3. *Two outside cylinders.*
4. *Triple cylinders* in which the two outside cylinders are separate castings from the inside casting. These are either bolted together flange to flange, or are bolted together with the frame interspersed between the inside and outside cylinder flanges.

This type of cylinder was shown previously on the horizontal boring machine.

Fig. 5 shows triple monobloc cylinders where the three cylinders, piston valve chamber, smokebox saddles, back cylinder covers and motion bar supporting brackets are all cast integral. The weight of this type of cylinder is approximately five tons.

The numerous cores required in a cylinder of this type present quite a problem for both the pattern maker and the moulder.

Complete patterns in wood of the whole of the outer surfaces are made, together with core boxes, in which can be moulded sand replicas of the whole of the inside surfaces, and in order to accomplish this it is the practice to lay out on large boards drawings of the various views showing all the internal steam passages, using a unit of measurement for the production of these layouts one-eighth of an inch per foot larger than standard (for cast iron cylinders) to allow for the contraction of the metal when cooling.

Fig. 6 shows the progress in the construction and building up of the mould.

Top left hand corner shows the sand core produced by the core box, with several smaller cores in position.

Top right hand corner shows the middle cylinder core and cores for the internal surface of the steam chests in position.

The cylindrical cores are built up with a hollow steel centre to allow any moisture or gases to escape.

This completes the first section of the moulding box, which in this case forms the top portion of the cylinder, and middle and lower portions are dealt with in a similar manner.

The weight of this casting, which has not an integral smokebox saddle, is 4 tons 15 cwts., but approximately 6 tons of metal are required in the process of casting.

It takes three days for the metal to cool sufficiently

Fig. 7. (*left*) Vertical milling machine with special port milling attachment.

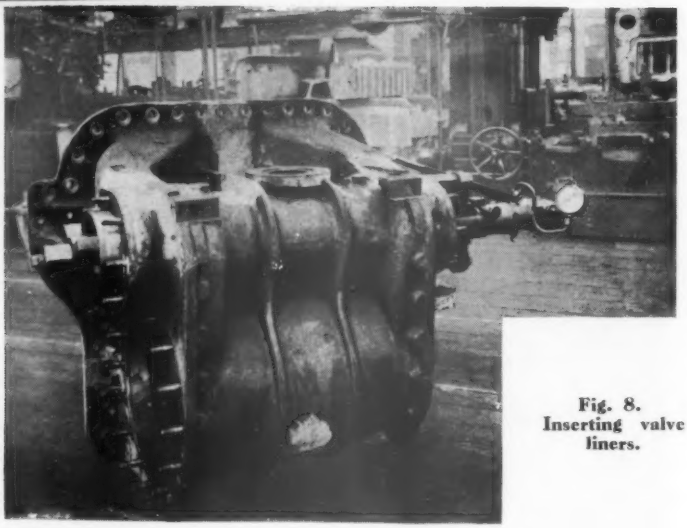
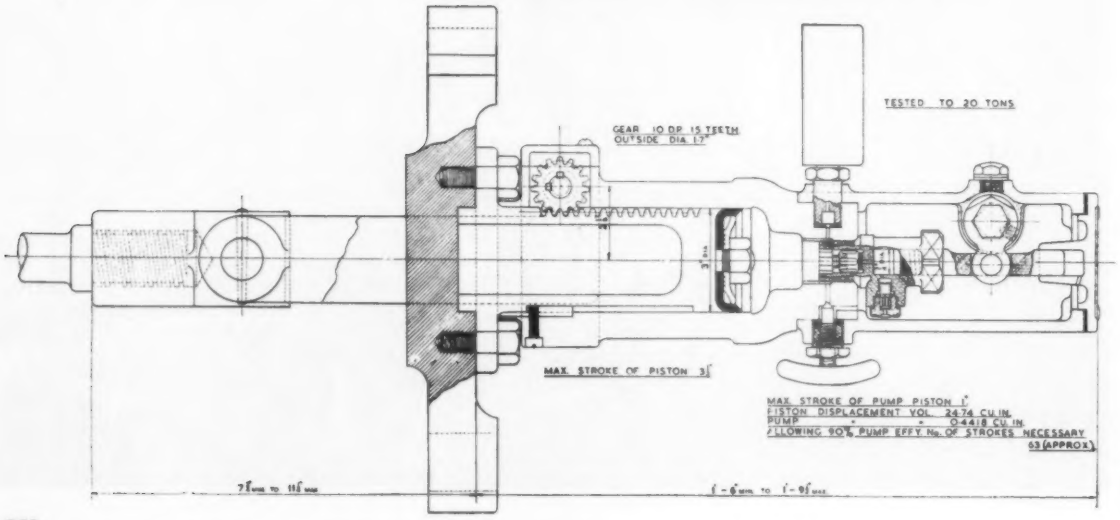


Fig. 8. Inserting valve liners.

Fig. 9. (*below*) Diagram of hydraulic liner inserter.


GEAR 10 DP 15 TEETH
OUTSIDE DIA 1.7"
TESTED TO 20 TONS
MAX STROKE OF PISTON 3"
MAX STROKE OF PUMP PISTON 1"
PISTON DISPLACEMENT VOL 2.474 CU.IN.
PUMP " " 0.4418 CU.IN.
ALLOWING 90% PUMP EFFY. No. OF STROKES NECESSARY
63 (APPROX.)

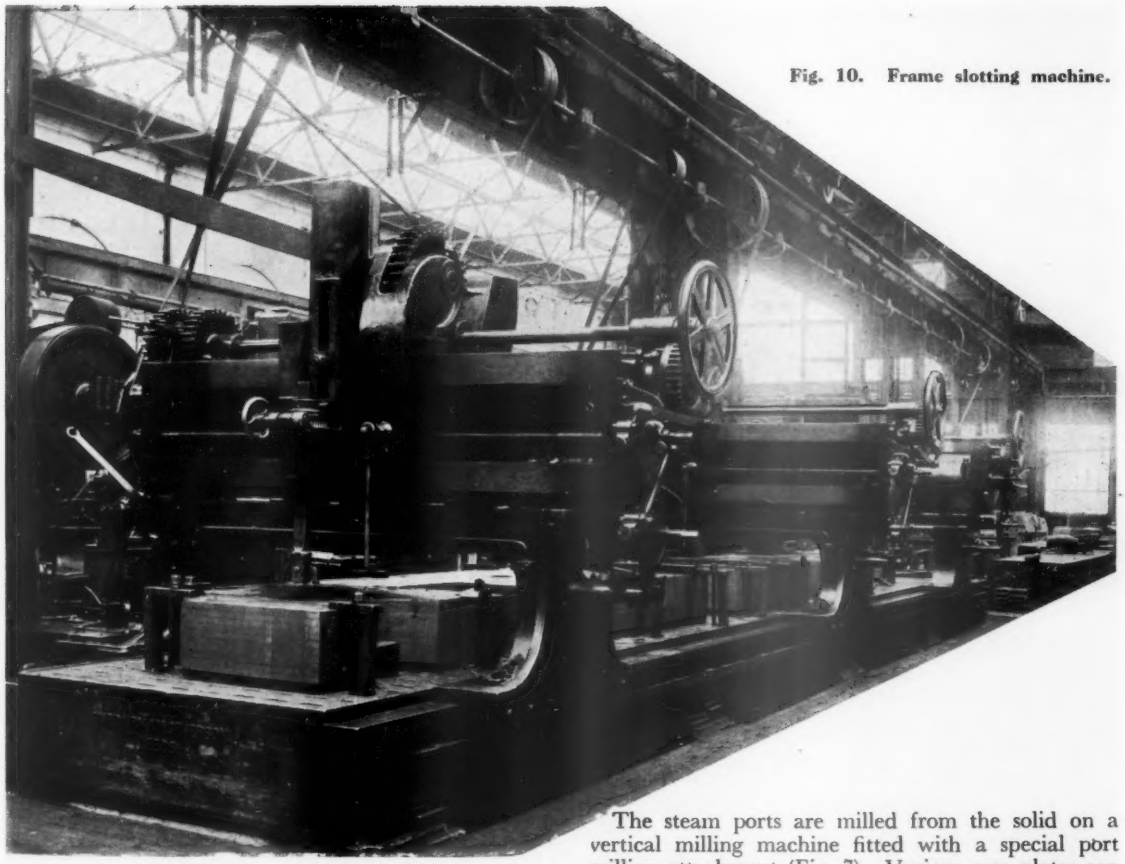


Fig. 10. Frame slotting machine.

to allow the casting to be taken from the sand. Controlled cooling is necessary to prevent uneven stresses being set up.

The bottom view, left hand, shows the casting being lifted from the sand; the lines of diversion of the pattern and moulding box can be distinctly seen.

From the time of pouring the metal until the casting is ready for the Machine Shop is approximately one week.

The bottom view, right hand, shows the finished casting in place in the engine frame.

I know of no example which better illustrates the advancement made in foundry practice in recent years.

Piston Valve Liners

Fitted in the steam chest of the cylinder on piston valve locomotives to afford an accurate surface for the movement of the piston valve are valve liners. These are close grained cast iron and vary in diameter from 8″ to 10″ on different types of locomotives.

The exhaust ports are cast in when received from the foundry. The liners are turned and bored on a semi-automatic or combination lathe, leaving .01″ in the bore for finish grinding. The grinding is carried out on a horizontal grinding machine using a 7½″ diameter stone.

The steam ports are milled from the solid on a vertical milling machine fitted with a special port milling attachment (Fig. 7). Various cam plates can be fitted to this attachment, to generate any shape of port from the plain rectangular type to the triangular type as shown. A four-bladed high-speed steel cutter is used for milling and paraffin is employed as a coolant.

The liners are pressed or drawn into the valve chamber by a hydraulic piston valve liner inserter of our own design (Fig. 8). This is a portable unit designed to give a maximum pull of 20 tons, the actual pressure of insertion being 6 to 8 tons; this pressure is recorded on a pressure gauge which is calibrated to read in tons on a 3″ diameter ram.

This illustration shows the liner inserter in position on an outside cylinder. The drawbolt through the valve chamber is attached to the crosshead of the inserter at one end, while the other end has a three-winged plate and nut which draws the liner into position, when the hand pump is operated.

Fig. 9 shows a cross section through the hydraulic inserter; the ¾″ diameter plunger draws the water (we have found soluble cutting oil to be more suitable than water) from the reservoir, as the 25″ long lever is operated. Applying simple hydrostatics to the design, it will be seen that an effort of 100 lb. at a leverage of 20 to 1 exerts a pressure of 4,627 lb. per square inch on the ¾″ diameter ram. As the load on the 3″ diameter ram is directly proportional to its

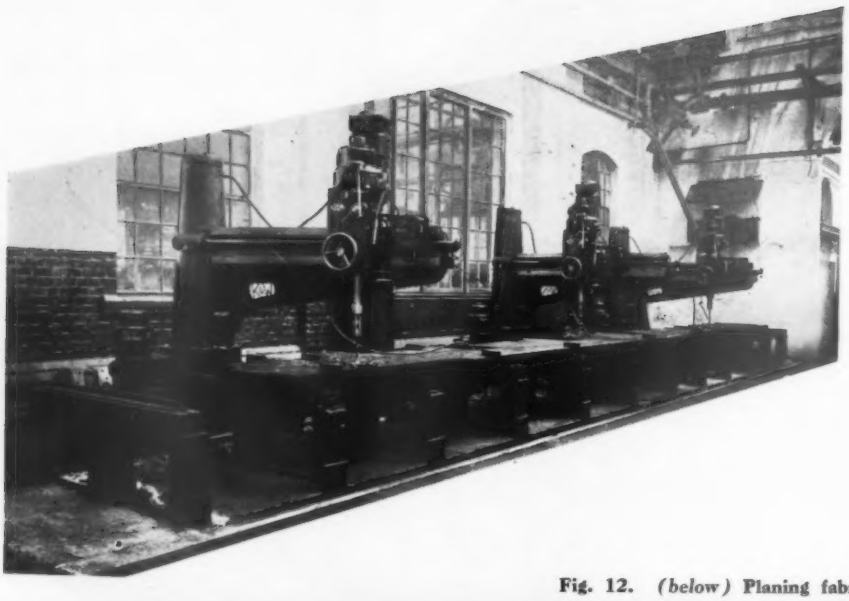
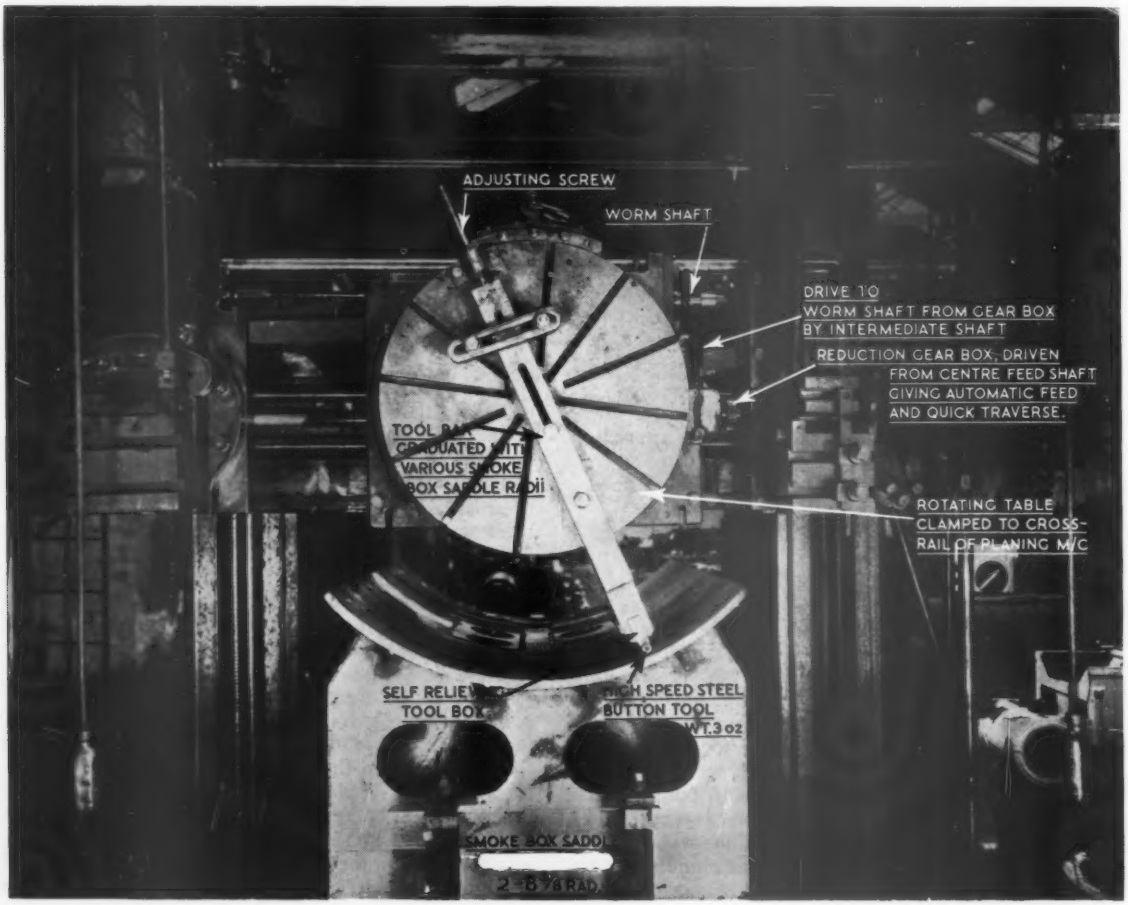


Fig. 11. **Frame drilling machine.**

Fig. 12. *(below)* **Planing fabricated smokebox saddle.**


ADJUSTING SCREW
WORM SHAFT
DRIVE TO WORM SHAFT FROM GEAR BOX BY INTERMEDIATE SHAFT
REDUCTION GEAR BOX, DRIVEN FROM CENTRE FEED SHAFT GIVING AUTOMATIC FEED AND QUICK TRAVERSE.
ROTATING TABLE CLAMPED TO CROSS-RAIL OF PLANING M/C
TOOL BOX
BUTTON TOOL
SMOKE BOX SADDL
2-8 7/8 RAD.

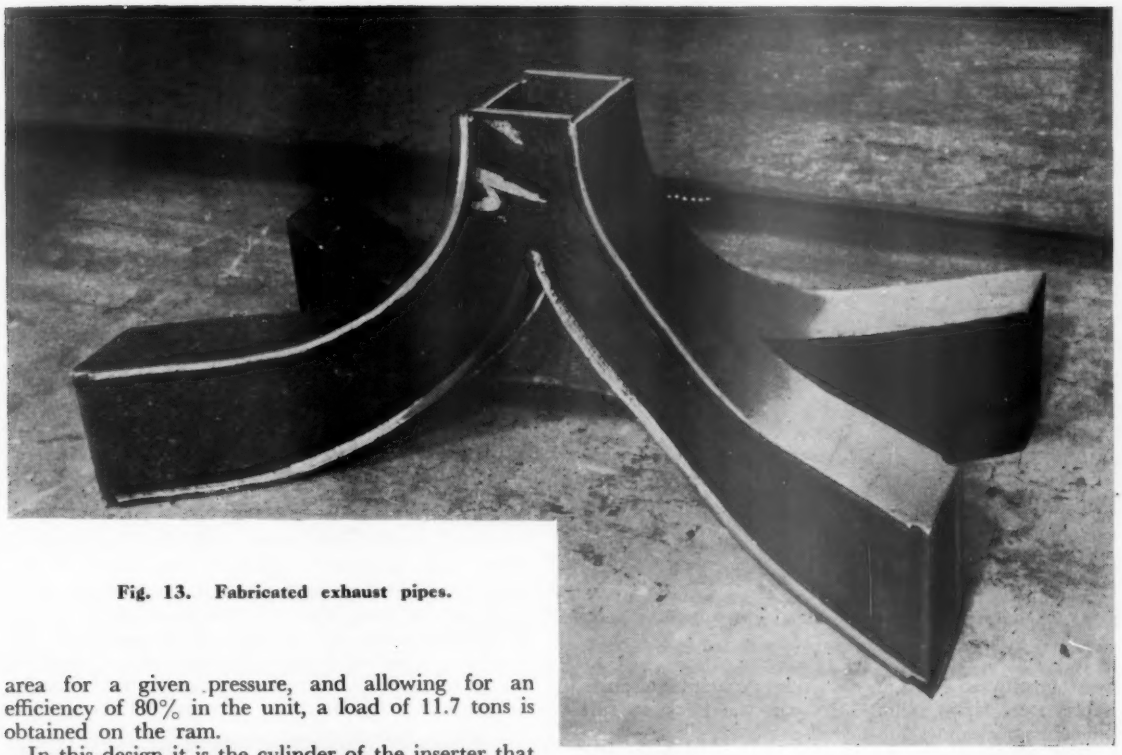


Fig. 13. Fabricated exhaust pipes.

area for a given pressure, and allowing for an efficiency of 80% in the unit, a load of 11.7 tons is obtained on the ram.

In this design it is the cylinder of the inserter that moves, not the ram, the ram being attached to a bridge across the end of the piston valve chamber and, as the cylinder moves backward under pressure, it draws the valve liner into position at the other end of the chamber. As this tool is portable and can be taken to any cylinder in the shop instead of transporting the cylinder to the tool, it is very useful for extracting worn liners, which require renewal, from repair locomotives.

Engine Frames

The foundation of a locomotive is the main frames and in this country it is the practice to manufacture these from steel plate of thickness 1″ to 1¼″, depending upon the size of the locomotive.

The plates received from the steel mill are marked off and flame cut to shape, leaving ¼″ on the edges for finish slotting where frame attachments are to fit. Each plate is then levelled and ten plates are stacked one on top of another on a large slotting machine, the top plate having been marked off from a template to the finished dimension.

The whole of the five pairs of frames are slotted at one setting, using the three slotting heads (Fig. 10). The edges of plates, where the attachments fit, are slotted to gauges, thereby eliminating hand fitting and grinding as far as possible.

The frames are then split into two bundles, three pairs and two pairs, and drilled on a triple headed radial traversing head drilling machine, using drilling jigs (Fig. 11). From practice it has been found that to drill the five pairs together is not an economical proposition, as extra specially long drills are required and too much time has to be spent clearing the cuttings from the drills, to prevent drill breakage.

Frame Attachments

On locomotives with two outside cylinders the space between the frames, at the front end, is fitted with a smokebox saddle. This acts as a frame stay, accommodates the exhaust branch pipes and the cradle portion serves as a support for the smokebox attached to the front of the boiler. These smokebox saddles vary on different classes of locomotives, being made from cast iron, cast steel, or by the most modern practice of fabricating from steel plate.

Fig. 12 shows such a saddle fabrication from 1″ thick plate having cast steel exhaust branch pipes welded in. Fabrication is carried out in two stages :-

1. the four sides and the bottom plate are welded together and the top edges of the plates are machined to take the cradle plate ;
2. the top cradle plate and the exhaust branch pipes are then welded in place.

After the final fabrication stage the saddle has to be machined on the two sides for the frame fit, and in the type shown in Fig. 12 the whole of the top surface of the cradle plate has also to be machined at a radius to suit the blast pipe base and the outside diameter of the smokebox. To do this, a radial planing attachment was designed to fit on to the cross rail of a " Hiloplane ". This attachment

Fig. 14. Fabricated smokebox saddle with pipes in position.

was constructed from an old milling machine circular table, steel strips being fitted on the back to suit the cross rail slides of the machine.

The gearing to produce the radial motion is so arranged that when this attachment is clamped to the cross rail, a spur gear on the attachment engages a split spur gear wheel which is fixed to the cross self-act shaft on the machine. By this method, all feed and quick power motions controlled by the pendant switch can also be obtained on the radial planing attachment.

On the front of the circular table is bolted a substantial planing bar. This can be adjusted to suit various radii required. Attached to the bottom of the bar is a spring-loaded, self-relieving toolbox which carries a circular button tool. This tool is made of high-speed steel and weighs only 3 ozs.

The frame fit is planed at the same time, with the side heads of the machine using smaller tool shanks fitted with button tools. All three tools are in operation together. Two cuts are taken down each side, as these have to be reduced from 1″ to $\frac{3}{4}$″ thick, to form a spigot to rest on the frame top, the depth of the cuts being 3/16″ and 1/16″ respectively at 1/16″ feed. One cut is taken on the cradle plate 1/8″ deep at 1/16″ feed. The table speed is five cycles per minute.

The need for greater economy in the construction of locomotives has prompted consideration to be given to introducing fabricated exhaust pipes in place of cast steel ones and Figs. 13 and 14 show a prototype saddle being constructed on these lines. The exhaust pipes are manufactured from $\frac{3}{8}$″ plate. By this design the cast steel exhaust blast pipe base, which was necessary in the former type, has been eliminated.

Although the introduction of the fabricated exhaust pipes will ultimately eliminate this item, I have included Fig. 15, which shows the machining of the underside of these blast pipe base castings to suit the smokebox saddle, as it may be of interest. This operation calls for convex planing and for want of a better name, I call this the "Lantern Slide Profile" attachment. As the name denotes, the profile plate fits into a transverse slot in a specially constructed vertical slide. This slide has no vertical screw; the top portion, which carries the toolbar, is controlled from a die block or roller which engages in the radial slot of the profile plate. The profile plate is anchored at one end by a link to the left hand cross rail head. This head is moved along the cross rail until the die block is on the vertical centre line of the profile, the tool being correspondingly set on the centre line of the casting. The head is then locked to the cross rail, the profile plate remaining set throughout the planing operation.

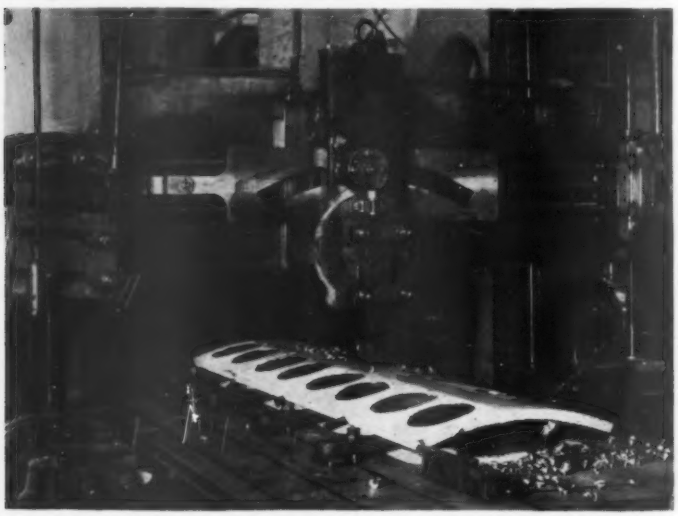


Fig. 15. Convex planing blast pipe base casting.

It will be seen that when the right-hand head is moved along the cross rail the profile plate controls the rise and fall of the top slide. With this arrangement it is possible to start the cut at one side, rise to the crown and fall to the other side, taking a 3/16" cut without trouble. Five base castings are usually machined at once, although only four are shown in this illustration. By turning the profile plate and die block upside down, concave planing can be performed just as effectively.

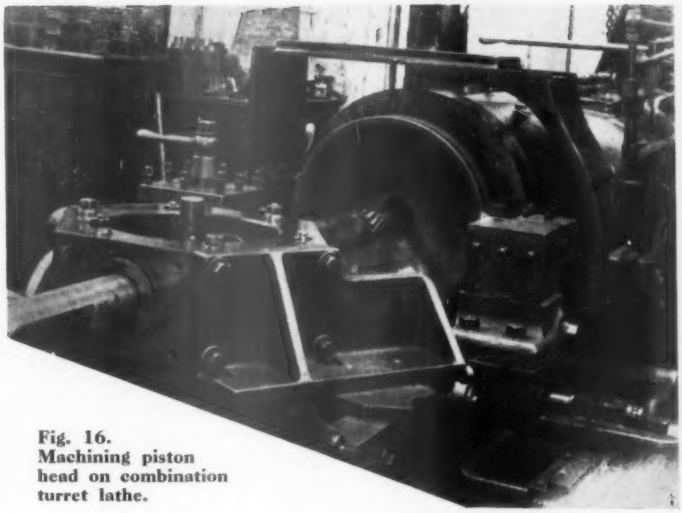


Fig. 16. Machining piston head on combination turret lathe.

Motion Gear

On a large number of modern locomotives the piston head and piston rod is a combined forging. The head is produced as a drop stamping with a short upraised trunk, to which is flash butt welded the bar which forms the piston rod. These are machined on large combination turret lathes.

Separate types of piston heads are also turned, bored and grooved for the piston rings on the same type of lathes.

The taper reaming operation for the piston rod bore is shown in Fig. 16. The bracket carrying the copy plate used when profiling the dish of the head is attached to the hexagon turret.

The roller follower is bolted to the cross-slide, a button tool having the same diameter as the roller being used for this profiling operation. The grooving tools for machining the ring grooves are mounted in the rear tool posts.

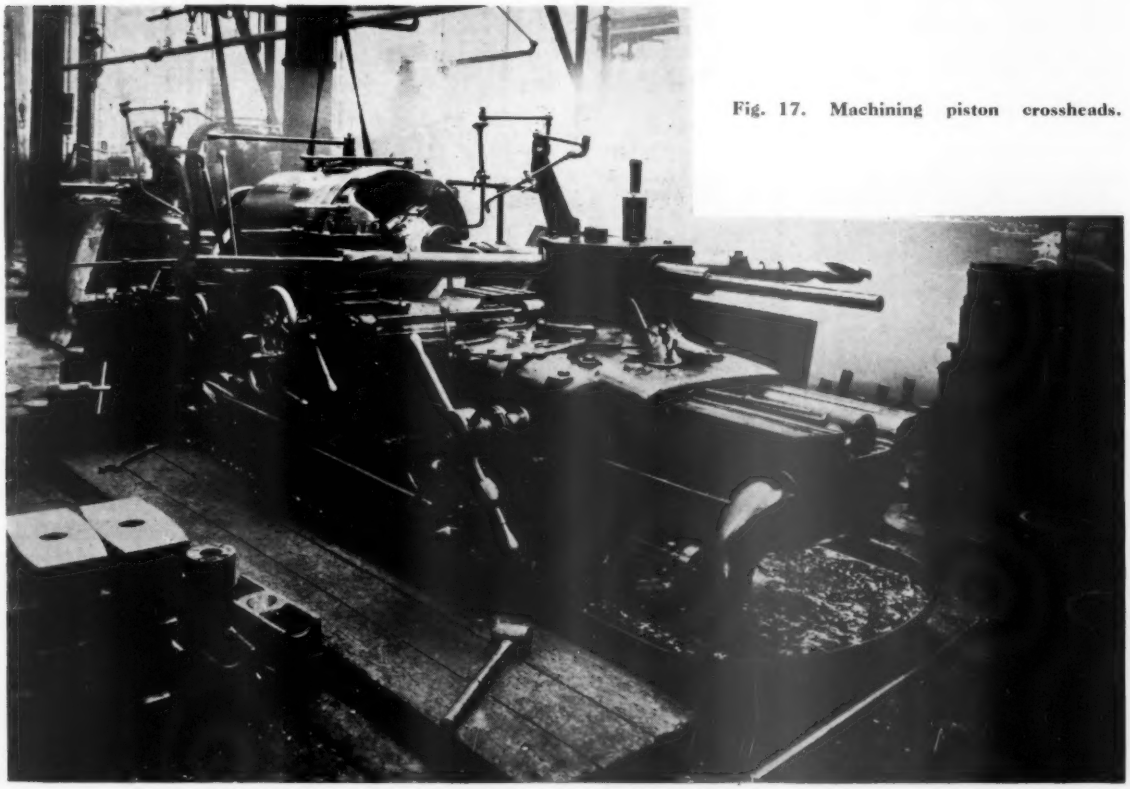


Fig. 17. Machining piston crossheads.

Fig. 18. *(below)* Operations on gudgeon pin bore.

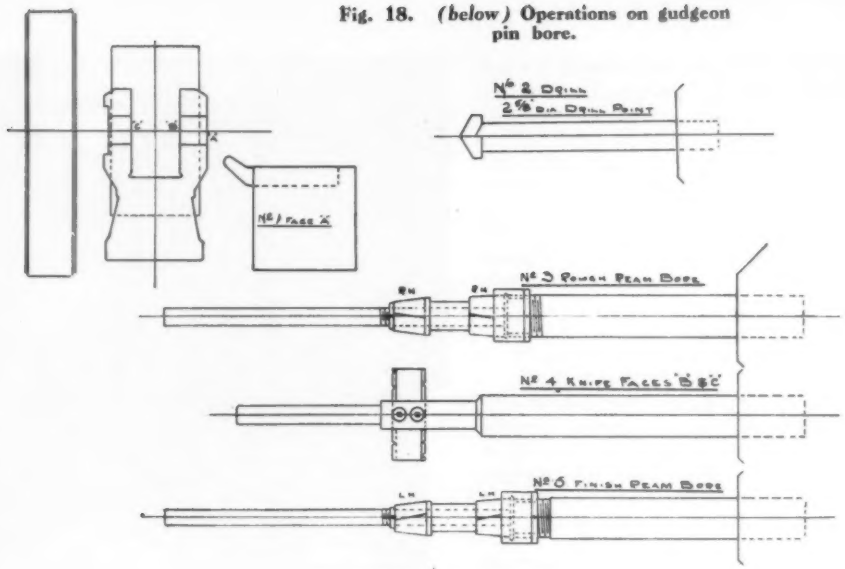


Fig. 21. *(right)* Diagram of extractor.

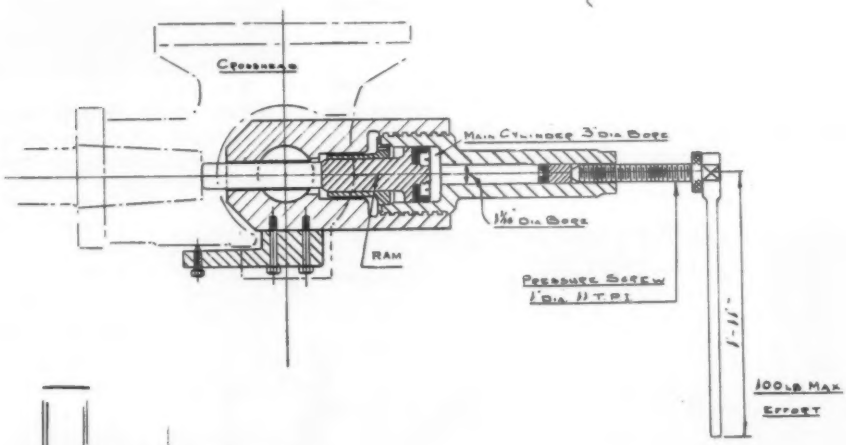
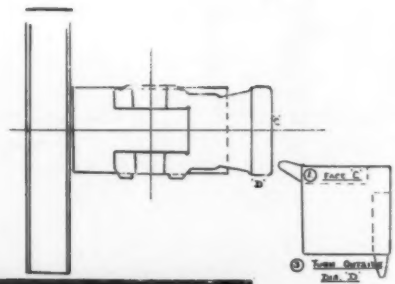


Fig. 20. *(below)* Crosshead extractor in use.



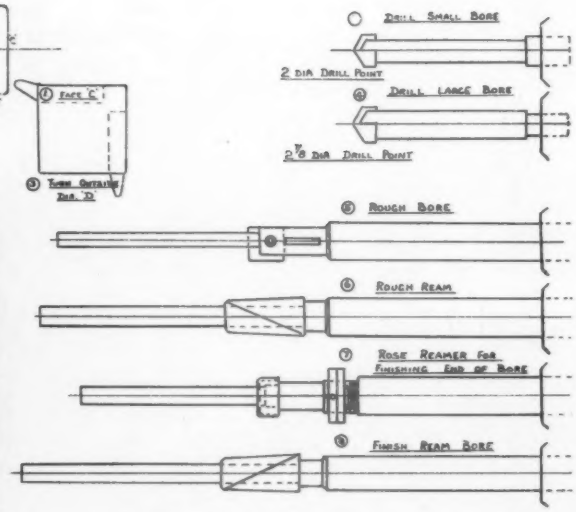


Fig. 19. *(above)* Operations on piston rod taper bore.

Piston rods are turned either on centre lathes or combination turret lathes and an allowance is left for finish grinding on the shank of the rod and also on the taper portion, which fits into the crosshead. The finish grinding is carried out on a cylindrical grinding machine, having a capacity of 9′ 0″ between centres and 25″ diameter swing over bed. The shank portion of the rod is ground to a manufacturing limit of –.001″ to –.003″, a tolerance of .002″.

Repair rods are also reground on this machine without removing the piston head from the rod (in the case of the separate type). They are ground in progressive sizes of .015″, and in the case of a 3½″ diameter rod, this can be progressively reduced to 3¼″ diameter before it requires replacing.

A large number of locomotives, including some of the British Railways standard types, are fitted with the three bar type of piston crosshead. This refers to the fact that the guide portion of the crosshead is in the form of a letter "T", having a broad motion bar at the top and the two smaller bars underneath. The crossheads are steel castings and these are first machined on the guide surfaces, which are subsequently used as location faces for the boring and turning operations (Fig. 17).

The crosshead is mounted in a special boring fixture as shown, the gudgeon pin bore being machined first. The crosshead is then located at right angles in the jig, using a special pin which fits into the gudgeon bore and engages a single eye projection on the fixture. This ensures the piston rod bore being machined in correct relationship to the gudgeon pin bore.

Typical tool set-up used on this type of work is shown in the following illustrations :-

Fig. 18 — Operations on Gudgeon Pin Bore

1. Face boss 'A' using tool in square turret.
2. Drill rough hole in casting using tip drill.
3. Rough ream compound taper bores using serrated taper reamers.
4. Face inside bosses using large knifing cutters with double cutting edges.
5. Finish ream taper bores 1 in 8 taper.
6. Check with taper gauge.

Fig. 19 — Operations on Piston Rod Taper Bore

1. Face end 'C' using tool in square turret.
2. Drill small bore using tip drill.
3. Turn outside diameter 'D' using tool in square turret.
4. Drill large bore.
5. Rough bore using flat cutter in boring bar.
6. Rough ream with serrated cutter.
7. Finish end of bore with rose type of reamer.
8. Finish ream taper bore at 1 in 21⅓ taper, which is equivalent to 3/64″ in diameter per inch in length.
9. Check with taper gauge.

After machining, the crosshead is pressed on to the piston rod with a pressure of 50 tons; under this load the end of the piston rod must be up solid at the bottom of the taper bore of the crosshead.

The cotterway for the taper cotter, which holds the piston rod and crosshead together, is then slot drilled through both crosshead and rod. Each time the cross head is parted from the rod for periodical examination, or repair, care must be taken when refitting to see that the crosshead is drawn on to the rod until the ends of the cotterway are in line, thus

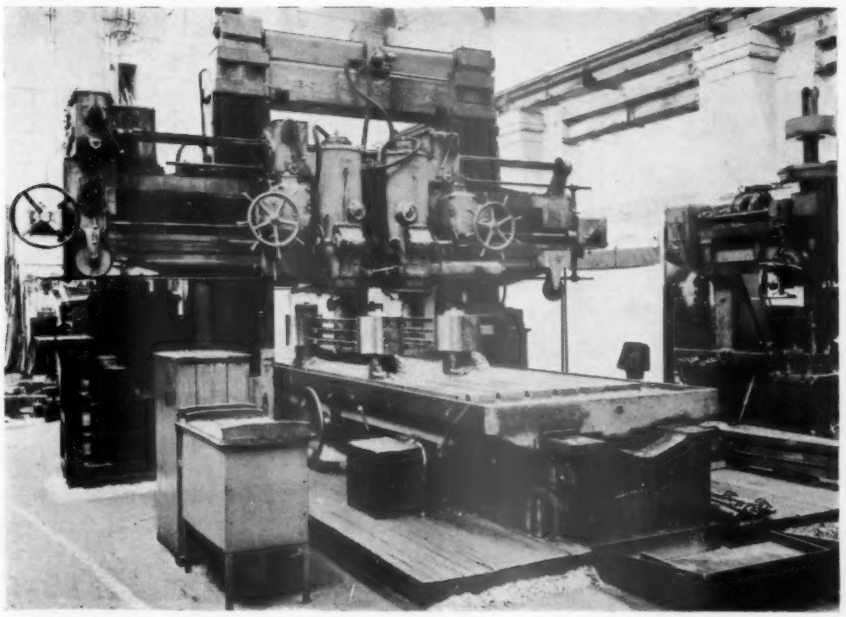


Fig. 22.
Vertical duplex profile milling machine milling six coupling rods at once.

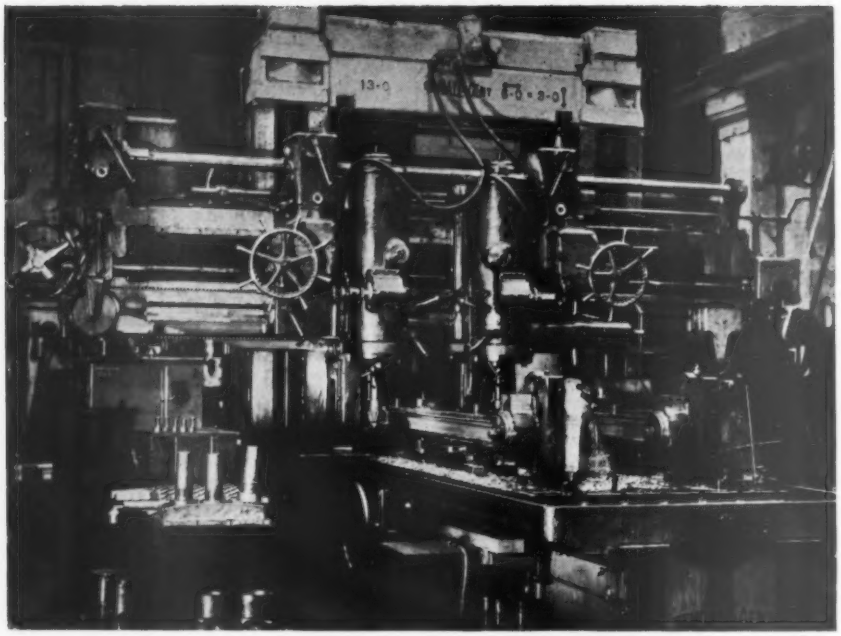


Fig. 23.
Milling the taper flutes on connecting rods.

ensuring that the desired pressure has been obtained.

To press the crosshead on to the rod or press it off again is a comparatively easy operation in the shop, where a horizontal hydraulic press is at hand, but when the locomotive has been in service for some time and the crosshead and rod have to be parted when in place, say in the Motive Power Depot, is quite a different story. This problem was overcome by the development of a greasedraulic crosshead extractor.

Fig. 20 shows the extractor applied to an outside crosshead, the crosshead having just been parted from the piston rod.

To extract a crosshead the small end of the connecting rod is dismantled and the single eye of the extractor is fitted between the jaws of the crosshead, using a special gudgeon pin with a transverse hole, through which passes the extraction plunger, which transmits the force from the main ram to the end of the piston rod. A diagram of the extractor is given in Fig. 21.

A ratchet lever, 1′ 11″ long, is applied to a 1″ diameter 11 threads per inch screw; this screw forces the 1.1/16″ diameter plunger fitted with a hat leather, forward, compressing the light grease, which is the medium used. This pressure acts on the main ram, which is 3″ diameter and with an effort of 100 lb. on the end of the ratchet, assuming 60% efficiency in the system, a calculated load of over 250 tons results on the main ram. This has proved a very efficient tool in service.

Motion and Valve Gear Components

Vertical duplex profile milling machines are extensively used for the production of motion and valve gear details. Fig. 22 shows a machining operation being carried out on a large duplex profile milling machine having a capacity of 13′ 0″ × 6′ 0″ × 3′0″. This machine is fitted for mechanically-operated profile milling, the conical roller on the cross-slide heads being kept in contact with the copy plate by counter-balance weights. A red 'tell-tale' light is provided to indicate to the operator that contact is being maintained between roller and copy plate during the longitudinal traverse of the table. Six coupling rods in two batches of three can be edge profile milled at once, using solid high speed steel cutters as shown.

The forgings for these rods are, in the main, manufactured in our own forges and given the necessary heat treatment to produce the physical properties required. They are then marked off to prove the forging and slab milled on both the ends and the shanks, on a large horizontal milling machine, two rods being dealt with at once.

The rods are then rough bored on a twin-spindle vertical boring machine, and then mounted on the milling machine on pillars, as shown, in two batches of three. In this position it is possible to profile mill round the whole of the rods with the exception of the boss at each end, without having to disturb the original setting.

Connecting rods are machined in a similar manner, only in this case the shanks of the rods have to be taper fluted.

For this operation the rods are mounted, as shown in Fig. 23, on special knee plate fixtures; the one carrying the large end of the rod has an adjustable vertical slide which facilitates the setting of the rods for milling the tapered flute or channel.

A high-speed steel staggered tooth milling cutter is used for this work, the profile of which is made to suit the shape of the channel at the small end of the rod.

After finish milling, the rods are finally bored to ensure correct centres and accurate bores for the bronze bushes on a twin spindle vertical boring machine, as shown in Fig. 24.

A length gauge is applied between the heads on the cross-rail and although the limit specified on the centres is ±.005″, this machine will produce well within this limit.

Eccentric rods for Walschaert valve gear are also milled on these large duplex vertical profile milling machines (Fig. 25). Four rods are dealt with at one setting, using the same knee type fixtures as used for the connecting rods.

A considerable amount of experimental work has been carried out with negative rake milling in locomotive components, but the successful applications are somewhat limited.

Fig. 26 shows an example where this technique has been successfully applied. The operation shown is the milling of motion bars 7¾″ width of face × 5′ 1″ long. The cutter is 10¼″ diameter and has teeth 10° negative helix and 10° negative side top rake.

The material has a tensile strength of 40 to 45 tons per square inch hammered forging, revs. per minute of cutter 156; feet per minute 418 and feed 7½″ per minute. This gives a feed per tooth of .008″. A maximum of 18 cuts approximately ⅛″ to ¼″ has been obtained per grind. The maximum amount of material removed per grind so far has been 1,300 cubic inches.

An excellent finish is produced, as can be seen from the bar at the side of the table.

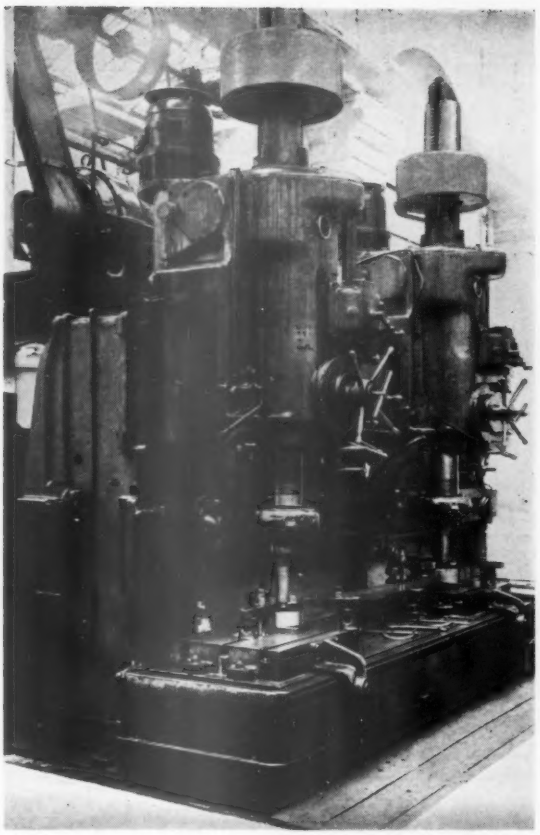


Fig. 24. Boring both ends of coupling rods.

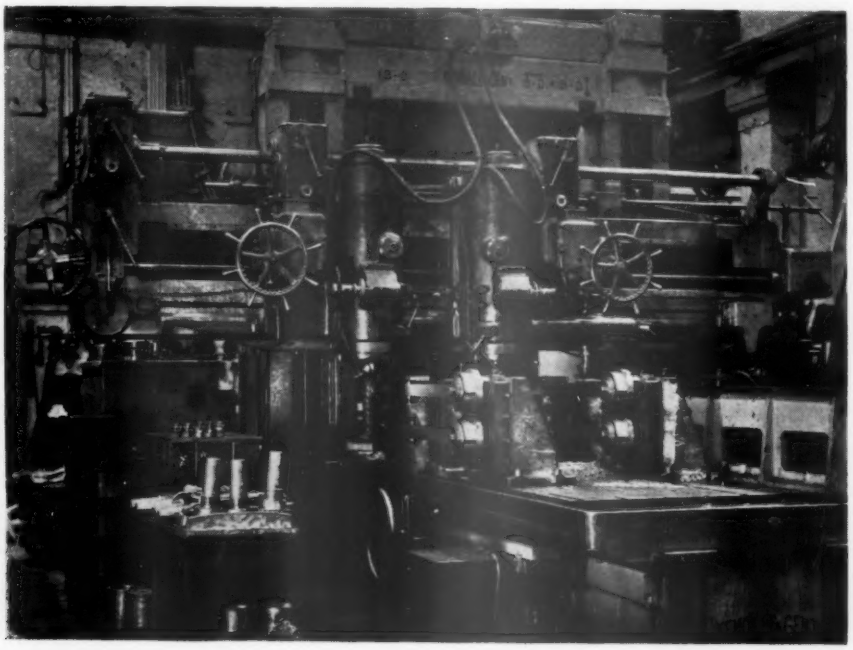


Fig. 25.
Milling eccentric rods.

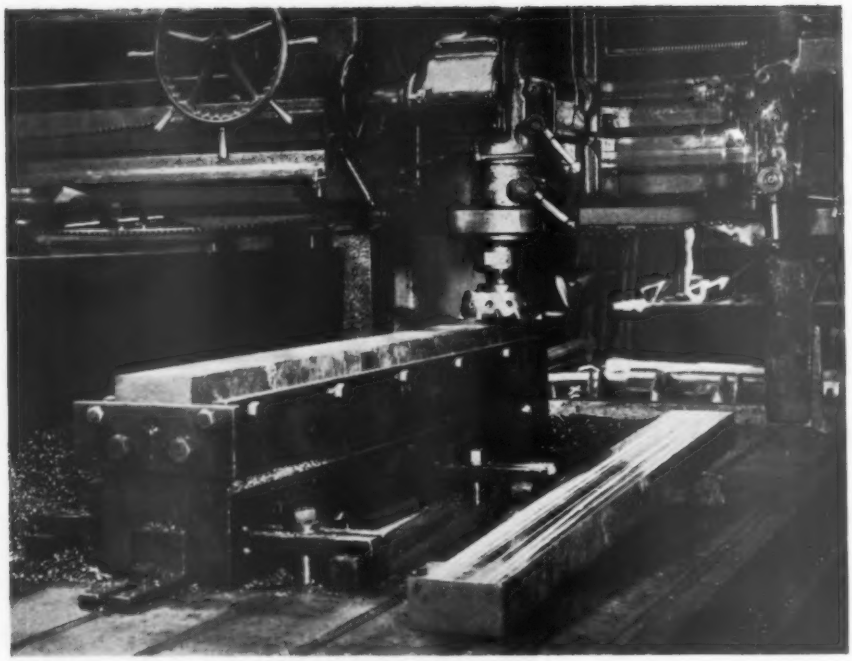


Fig. 26.
Negative rake milling of motion bars.

Wheels and Axles

Driving wheels with built-up crank axle for modern three-cylinder locomotives present some very interesting production problems. A high degree of precision is necessary in machining and assembly, and also in the selection of suitable material from which the various components are manufactured in order to ensure immunity from failure, together with a reasonable life in service.

Machining and Assembling

The crank webs are of 45 to 50 ton tensile steel, purchased from outside contractors, very roughly sawn or slotted to the required profile. The machining operations are then as follows :-

1. plane to thickness, giving a fine finish on both sides;
2. mark off profile from template;
3. slot profile four at once (see Fig. 27);
4. bore for crank pins and shaft components, four at once (see Fig. 28).

This illustration shows the four webs being bored in a jig to ensure correctness of centres. An allowance is left in the bores for final grinding to standard nominal dimensions.

The shaft components are made from 32 to 38 ton tensile steel and the centre crank pin from 42 to 50 ton tensile steel.

Fig. 29 shows a crank building fixture. This is the fixture used for assembling built-up cranks. The seating on the shaft and crank pins where the webs fit are finished to nominal diameter plus .018" and the webs are heated by an internal helical gas and compressed air burner which is inserted in the

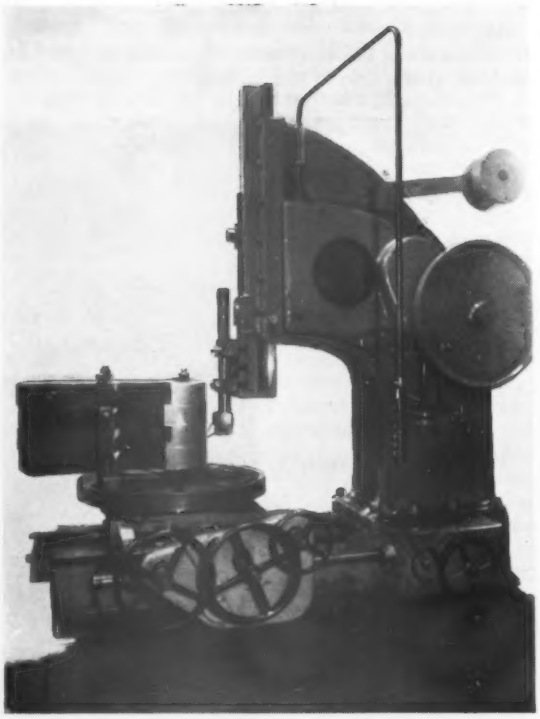


Fig. 27. Slotting outside profile of crank webs

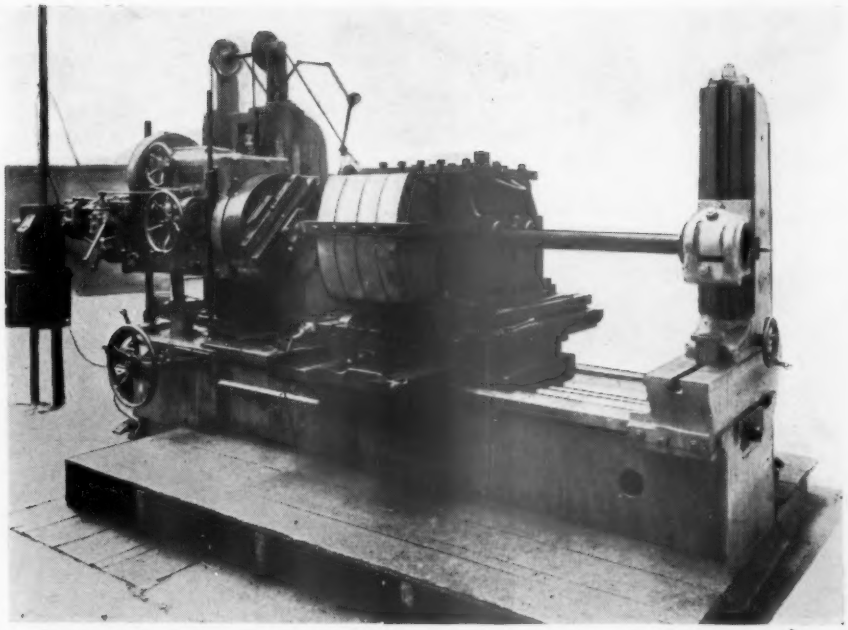


Fig. 28.
Boring of crank webs

bore of the webs as shown. When the necessary amount of expansion has been obtained, the component is moved into the web by the traverse screw and hand wheel and the web allowed to cool. The sequence of shrinkage is as follows :-

1. both shaft components are assembled to the two webs;
2. the centre crank pin is then assembled to the first web and shaft;
3. the second shaft and web is then assembled.

A half-and-half dowel is then drilled and tapped into each mating fit and flush screwed dowels fitted.

After assembly the crank is finish turned on the wheel seats to suit the bore of the wheels and then milled for keyways, which define the correct relative position of outside crank pins to each other and also to the centre crank pin on three-cylinder locomotives.

The wheels are then pressed on by a large horizontal hydraulic press of 400 tons capacity, as shown in Fig. 30, the tonnage being recorded automatically on a chart which is kept for reference purposes. The tonnage used ranges from approximately 10 to 15 tons per inch of diameter of wheel seat.

After the tyres are bored they are heated by special gas burners disposed equally round the outside circumference and when the necessary expansion has been obtained, the accommodating wheel centre mounted on its axle, which is in a vertical position, is lowered by a crane into the heated tyre. After

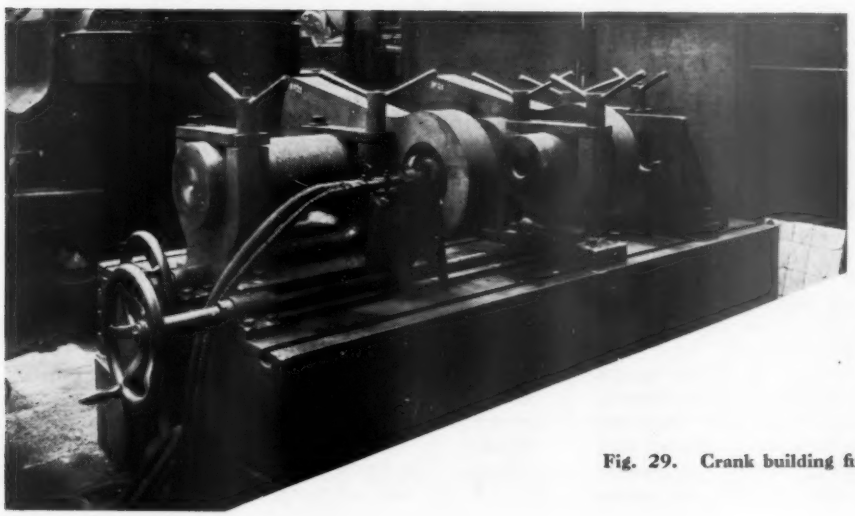


Fig. 29. Crank building fixtures.

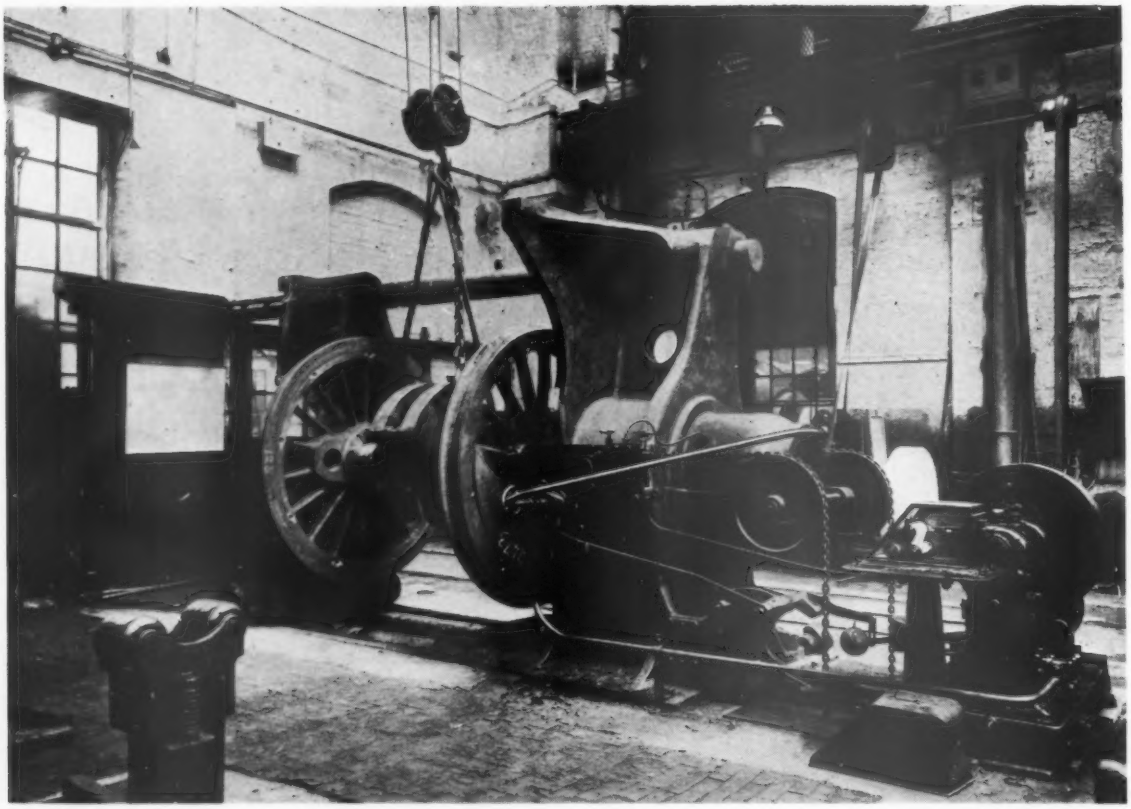


Fig. 30. Wheel press.

cooling, the adjacent tyre is dealt with in a similar manner. To ensure the correct shrinkage has been given, the circumference of the tyre is measured by a steel tape which is applied in a narrow parallel groove turned in the tread of the tyre during the boring operation, firstly, before the tyre is heated and. secondly, after the tyre has cooled on the wheel centre, the difference indicating the shrinkage applied.

Quite a large number of locomotives have the tyres riveted to the wheel centre in addition to the shrinking and Fig. 31 shows a special machine designed for pin riveting. Hot rivets are used and the advantage with this method is that plain pieces of bar can be used in place of a headed rivet.

The bars of the correct length are heated all over in a small rivet furnace. They are then inserted into a rivet hole and the head of the machine moved into position, and when the hydraulic pressure is applied, the countersunk heads of the rivet at both sides are formed almost simultaneously.

The principle of 'pin riveting' is by no means new, as it was applied to a number of boiler riveting machines before the War. In the previous applications, however, a combination of springs and hydraulic pressure was used to obtain the motion necessary for the dual formation of both rivet heads.

In the machine under review, the whole of the riveting motion is performed by hydraulics. The three diagrams in Fig. 32 illustrate the operation of forming both rivet heads.

The frame of the riveting head is mounted on a top slide and is free to move under hydraulic pressure in a direction parallel to the axis of the wheel rivet. The positioning of this head in both directions is by rack and pinion. After the heated piece of bar, which is to form the rivet, is inserted into the hole in the tyre and wheel centre, the column of the machine is first moved into postion until the riveting snaps are co-axial with the rivet bar. The riveting head is then moved by the rack and pinion until the hydraulically controlled stop 'S' abuts the inside of the wheel centre. The relative distance between the face of the stop and the end of inside riveting is set to give the correct projection of bar on the inside, to form the inside rivet head.

When hydraulic pressure is applied to the main cylinder 'T', the outside rivet snap forms the outside head until the load on the gradual cooling head is greater than the resistance offered by the stop cylinder 'S', which is always open to hydraulic pressure. The frame of the riveting head then moves on the top slide allowing the inside rivet snap to

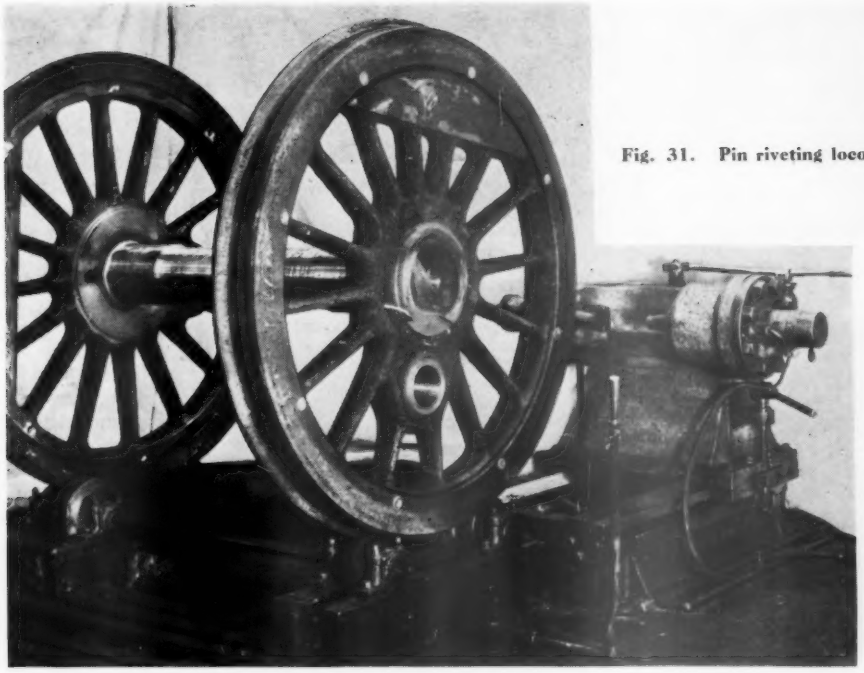


Fig. 31. Pin riveting locomotive tyres.

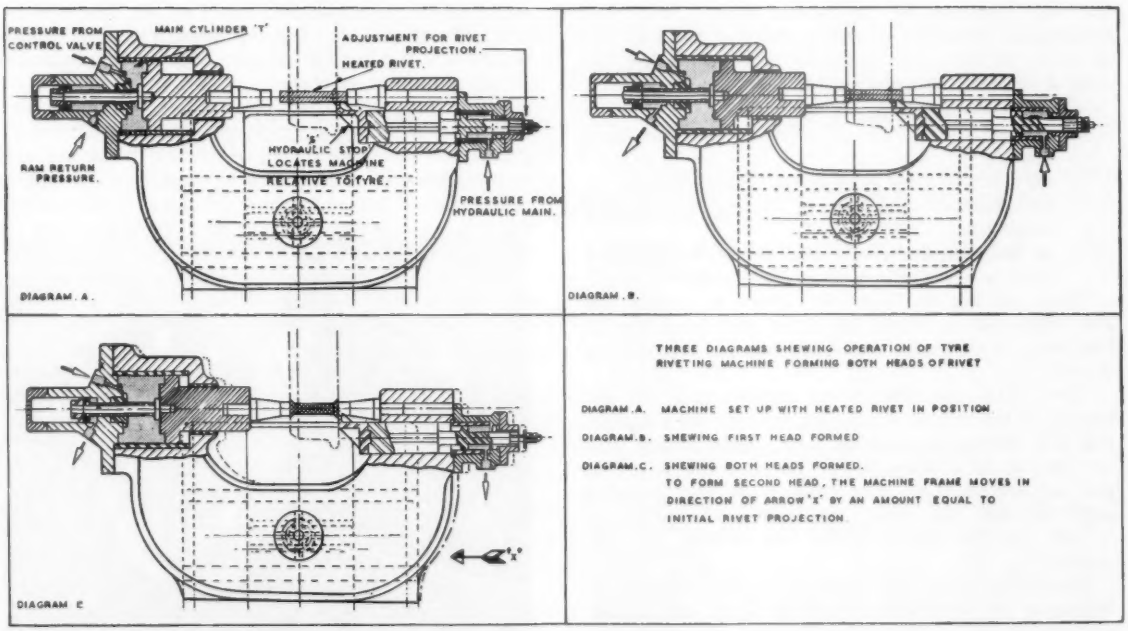

PRESSURE FROM CONTROL VALVE
MAIN CYLINDER 'Y'
ADJUSTMENT FOR RIVET PROJECTION.
HEATED RIVET.
HYDRAULIC STOP LOCATES MACHINE RELATIVE TO TYRE.
RAM RETURN PRESSURE.
PRESSURE FROM HYDRAULIC MAIN.
DIAGRAM. A.
DIAGRAM. B.
DIAGRAM. C
THREE DIAGRAMS SHEWING OPERATION OF TYRE RIVETING MACHINE FORMING BOTH HEADS OF RIVET
DIAGRAM. A. MACHINE SET UP WITH HEATED RIVET IN POSITION
DIAGRAM. B. SHEWING FIRST HEAD FORMED
DIAGRAM. C. SHEWING BOTH HEADS FORMED.
TO FORM SECOND HEAD, THE MACHINE FRAME MOVES IN DIRECTION OF ARROW 'X' BY AN AMOUNT EQUAL TO INITIAL RIVET PROJECTION.

Fig. 32. Diagram showing operation of pin riveting machine forming both rivet heads on tyre rivet.

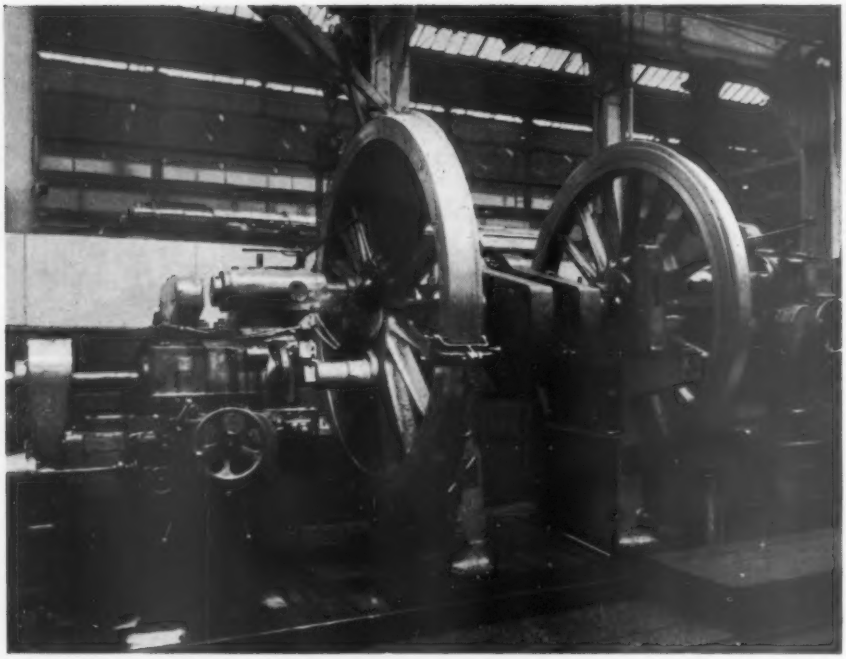


Fig. 33.
Crank pin boring and turning machine.

form the inside rivet head, until the resistance offered by the second head is greater than the first, the final result being that the rivet is squeezed tight with the full pressure of the main ram. From the description this may seem a lengthy process, but in point of fact, the operation is so quick the eye cannot discern the movements.

The advantages of this method are :-

1. saving in the cost of forming the first rivet head;
2. only one heating is required instead of two;
3. formation of scale due to heating is kept to a minimum;
4. as both heads are formed to the countersunk holes a better fitting rivet is obtained.

After riveting, the tyres are turned to profile and the wheel centres bored for crank pins on a special horizontal boring and crank pin turning machine as shown.

The actual operation being performed is the re-turning of the outside crank pins for both the coupling rod and connecting rod journals. Both outside pins are turned simultaneously. The machine is set to give an accuracy of $\pm 2\frac{1}{2}$ minutes in the included angle between the crank pins and an accuracy of $\pm .005''$ in the throw of the pin relative to axle centre (Fig. 33).

Notwithstanding the fact that the theory of balancing of locomotive wheels is fully and widely understood, wheels " balanced " purely by calculation are rarely if ever correct when tested on a dynamic balancing machine. Machines suitable for locomotive wheel balancing were first introduced in the railway works in this country in 1914 by Mr. G. J. Churchward, of the Great Western Railway, and whilst the machines in use today have been modified in detail, the principles laid down by Mr. Churchward are still adhered to. Fig. 34 shows a pair of driving wheels of a two outside cylinder engine being balanced in one of these machines.

It will be noted that circular weights have been added to the outside crank pins and to the return crank pin, these being equal to the revolving and a proportion of the reciprocating mass of the rods.

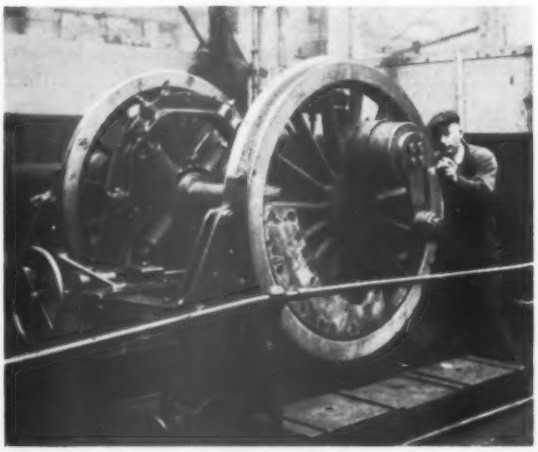


Fig. 34. Wheel balancing machine.

The counterbalance weights are either cast solid with the spokes of the wheel, or are built up by crescent-shaped plates riveted at either side of the wheel centre with the necessary amount of lead, filling the space between these plates and adjoining spokes.

The axle journals are suspended in bronze and white metal bearings housed in spherical outer bearings. The split housings accommodating this outer spherical bearing are supported on four springs at each side, so arranged that the bearings may float or dither with the axle when the wheels are out of balance.

The bearings and their springs are supported in cast steel frames, split on the horizontal centre line to permit the wheels to be inserted into the machine. The whole of the arrangement provides a fully universal mounting; tie rods are, however, provided to limit the amount of float, from the true axis of the machine.

The wheels are driven by a 35 h.p. variable speed motor, through a fully universal telescopic shaft which is fitted with the Hookes type of joint at each end. The joint at the wheel end is attached to a driving plate, which is centralised by a coned plunger fitting the axle centre, the driving plate being bolted to the spokes of the wheel.

Air brake equipment is provided using 80 to 90 lb. pressure on an 8" cylinder, two brake blocks to each wheel. This is fully compensated, all four blocks being applied together. A hand wheel adjustment is provided to enable the blocks to be set to suit different diameter wheels and this can also be used as a hand brake if gradual application is necessary.

The method of balancing is gradually to increase the speed of rotation in a clockwise direction until one or both wheels begin to dither or dance in the housing. The position of maximum out-of-balance is found by holding a piece of chalk on the tread of the tyre. The process is repeated with the wheels revolving in an anti-clockwise direction. The two maximum out-of-balance points are then bisected and this is the mean out-of-balance position which requires counter-balancing.

Small additional temporary weights are then added and the process repeated until the wheels can be run up to approximately 60 miles an hour in either direction without any sign of out-of-balance. The amount of the additional weight is then calculated, and a corresponding adjustment is then made to the balance weight on the wheel by either adding or drilling out the required amount.

Conclusion

It will be appreciated that the foregoing production methods are not common to one type of locomotive, but are in everyday use in the production and maintenance of a number of different types.

In closing, the Author wishes to thank the British Transport Commission, and in particular, Mr. K. J. Cook, the Chief Mechanical and Electrical Engineer of the Eastern and North Eastern Regions, for permission to give this Paper, and also the South Kensington Science Museum for permission to use the photograph and description of the early boring machine.

THIRD CONFERENCE ON AIRCRAFT PRODUCTION

The proceedings of the Third Conference on Problems of Aircraft Production, held at Southampton on 14th and 15th January, 1955, and published in the March and April issues of the Journal, may now be obtained, separately bound, at 10/- a copy, post free. As only a limited number are available, those who would like copies, and have not already ordered them, are requested to advise the Secretary, at 10, Chesterfield Street, London, W.1, as soon as possible.

Remittances should be made payable to "The Institution of Production Engineers".

ZINC DEVELOPMENT ASSOCIATION

It is announced that the Zinc Development Association and its affiliates, the Hot Dip Galvanizers, the Zinc Alloy Die Casters and the Zinc Pigment Development Associations, have removed their offices from Oxford to: 34, Berkeley Square, London, W. 1. (Tel: GROsvenor 6636.)

It is planned to arrange in the new premises a permanent exhibition of zinc and zinc products, which will eventually be open to the public.

JOURNAL BINDERS

The Institution is now able to supply the larger size of binder for loose copies of the Journal. Each binder will take twelve Journals.

Binders may be ordered from Head Office, price 10/- each, post free.

RESEARCH PUBLICATIONS

A number of copies of the following Research publications are still available to members, at the prices stated:

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research and Management	10/6
Practical Drilling Tests	21/-

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge", Melton Mowbray, Leics.

SOME PROVOCATIVE THOUGHTS ON AIRCRAFT TOOLING METHODS

by S. P. WOODLEY, M.B.E.

Presented to the Southampton Section of the Institution, 18th November, 1954.

Mr. Woodley has been Superintendent at Vickers-Armstrongs, Limited, Supermarine Works since 1950.

He commenced his apprenticeship with Supermarine Works in 1927, and has served the Company in various capacities.

During 1942/43, he was a member of the Fedden Mission, which was formed under the auspices of the Ministry of Aircraft Production to investigate technical problems and new developments in the United States of America.

Mr. Woodley was one of the speakers at the Second Conference on "Problems of Aircraft Production", held at Southampton in 1953.

AS production engineers, engaged in the manufacture of aircraft, we are all too aware of the immense amount of time and labour involved in the tooling up of a new type of aircraft. This is one of the factors which is increasing the time it takes us to get into production. Of course, the incidence of changes and modifications has its effect upon the tooling up period insofar as it becomes necessary to make constant changes to the tooling, very often necessitating the scrapping of complete sets of tooling and starting all over again. If the tooling concerned is simple, then the changes involved are not so great, and little delay is involved.

Any relief to be obtained from the complex requirements of tooling which the present day aircraft involves, combined with a more simple form of tooling, will shorten the period between design and production. The present complexity which we meet in the design of aircraft today is an unfortunate necessity brought about by increased speeds and the requirement that the aeroplane shall be a deadly fighting weapon. If we are to have the best possible aircraft, that aircraft must necessarily be complex since, as speeds increase, more and more is added to the aircraft in the way of ancillary services, radar, new weapons, and pilot survival devices, etc. Accepting the fact, therefore, that we cannot escape from an increase in design requirements, we must look elsewhere for relief from the almost intolerable tooling burden which this complexity brings.

This can only come from an investigation into production methods with a view to simplification and revolution. A revolution in manufacturing methods is what is required at the present moment. The production methods which have served us so well in the past are now out of date in the light of our new requirements, as being too time-consuming and requiring too much in the way of tools and control. Happily, there are signs which lead us to believe that the automatic factory is not a dream, but will be realised much more quickly than many of us think.

Lack of New Ideas

When we consider the ever-accelerating changes which we have seen in the span of our own lifetimes, it is a matter for marvel that we in the aircraft industry are so little concerned to change our traditional methods. Let us consider what new

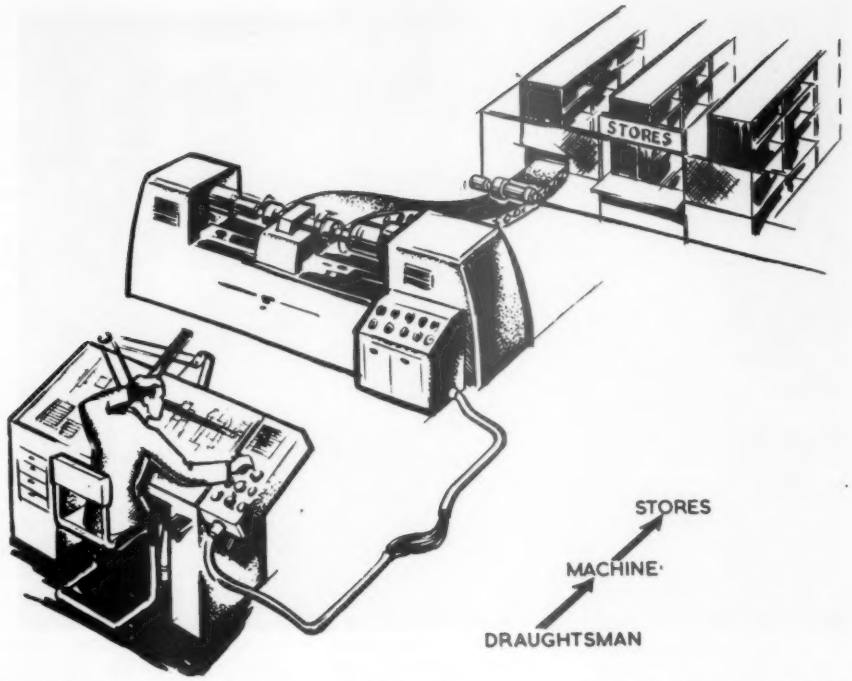


Fig. 1.

production ideas have been developed for the production of aircraft components during the past 30 years. I think that you will agree that they can be counted on the fingers of one hand. As a body of engineers, I assert that we have not given enough thought to our problems. We have been well content to use time-honoured production techniques, even though some of these are now uneconomic and wasteful. Some 25 years ago, the all-metal aeroplane came into production, and as a consequence new techniques were devised more suitable to metal rather than wood construction. There have been few developments since then.

We are now starting on an entirely new field of construction which may eventually develop into the manufacture of aircraft major components from thick slabs of light alloy, i.e., the machining of whole wing sections from solid material. Even this is only a beginning. As higher speeds are reached we most certainly will have to use such new materials as titanium and steel, and methods of fabricating components from these materials easily, will become necessary.

Traditional Methods

Ordinary hand methods of forming the sheet metal parts were considered good enough in the main until the emergency war expansion in 1938. Owing to the vast increase in the numbers of aircraft to be manufactured, the tooling then became much more productionised, and we saw a large scale introduction of complex press tools, machine set-ups and specialised machine tools which cut down the production times of individual components considerably. This type of approach to the problem is expensive and suitable mainly for large scale production. The introduction of the rubber press came some little time before the War and involved an entirely new technique for the production of formed parts, by using the plastic flow of rubber under pressure to form parts around a die block. Out of this method have come the recent developments of the Verson Wheelon press and the Marform or Hydroform processes, but these cannot really be said to be new methods.

Another new development was the stretcher press. In this a die block is forced into material which is held in constraint, thus making the sheet metal assume the form of the die block, as it is strained past the elastic limit. Again, a development arose out of this in the form of the Hufford stretch wrapping machine. In this machine the material is stretched between jaws until it is in the plastic flow condition, and in this state it is wrapped around a form block.

Some of the production methods which I have outlined are thus only developments of the three basic ones, which are, the router, the rubber press and the stretcher press.

Until very recently, there have been no new ideas at all for the production of machine shop items. Now we are faced with a positive and dramatic trend in airframe design, which involves the use of machined items rather than those which are fabricated from sheet metal. These machined items are complex shapes in light alloy or high tensile steel.

New Design Requirements

What design has done has been to take a part, as for example, a wing, a fuselage frame, a bulkhead, etc., which traditionally was fabricated from a large number of sheet metal items, and design this in very

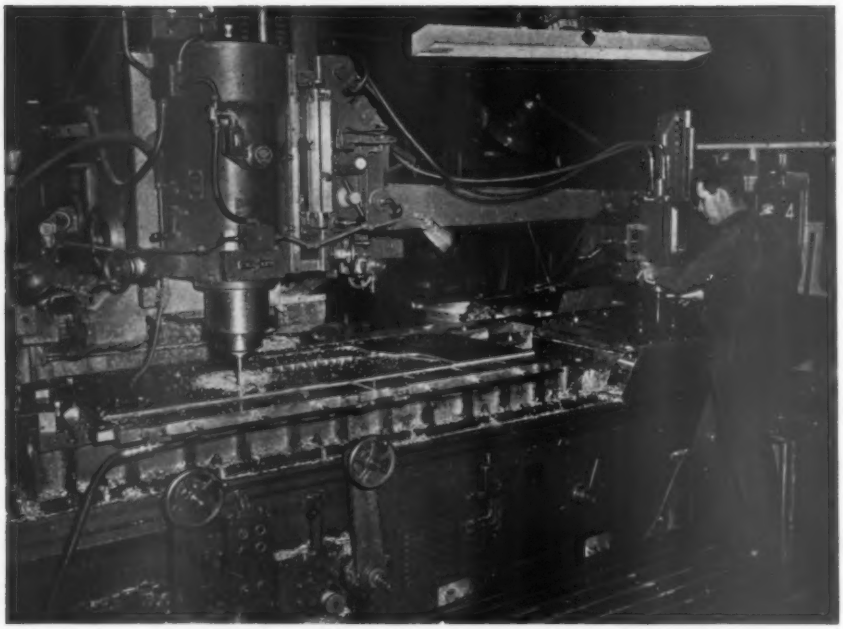


Fig. 2A.
Cincinnati Hydrotel engaged on the production of integrally machined control surface skin. Note vacuum holding chuck.

similar form as one piece. This involves the complex machining of rebates, reliefs, flanges, bevels and curved surfaces, etc. on large billets or forgings of light alloy. A large number are also now required in high tensile steels.

Using traditional methods, the tooling involved in producing fixtures and drill jigs for these large items is enormous, and some way has to be found to eliminate this costly tooling. The ideal which we should seek is the automatic factory, where we have a drawing board with a designer, a machine, and a stores bin. The drawing that the designer produces is fed into the machine which completely and automatically manufactures the part, which falls into the stores bin ready to receive it (Fig. 1).

The human element in this set-up is no longer the operator but the designing brain. This is what man can best do. A machine cannot yet think out an entirely new conception. It cannot paint a picture, admire a sunset or design an aircraft. On the other hand, the man cannot beat the machine when it is made fully automatic. I know this reduces the problem to an absurdity, but it forcibly illustrates what I mean.

New Production Methods

I am saying that there is an urgent need for much more thought and ingenuity to be applied to our problems in order to ease the production task, with a special reference to the need for simplification of tooling. There is an immediate need for novel production techniques, and the more novel the better. The trend towards complex machined items, instead of an assembly of many small pieces which may be a combination of parts fabricated from sheet metal and machined items, is a healthy one, because it tends to cut down the number of parts. With an assembly fabricated from a large number of small parts made from sheet metal, a considerable amount of tooling is involved, because each item requires several tools in order to manufacture it. In addition, an assembly fixture is required in which all the items are brought together, to control and fabricate the finished assembly. With the machined part, however, no assembly fixture is generally required, and with the adoption of new techniques, very little in the way of tooling is needed for the machining processes. We also have a lighter and stronger component because a part machined from one piece is bound to be stronger and lighter than a part built up from many pieces.

By adopting new techniques, a few simple templates can be made to control the manufacture of the parts, and there is an even newer and exciting development, which is just appearing. This is the control of machine tools using a magnetic tape, or a punched tape. If the tooling is made as simple as this, then design changes can be readily accommodated without the disruption of production which occurs if complicated machining fixtures have to be modified. The amount of complexity and work involved in machining components from the solid may seem at first sight to be tremendous. But it is a step in the right direction because, sooner or later, the problem will be solved and what was once an extremely difficult machining job will become routine.

Profile Machining

Most of these new parts are produced by some variation of the milling function. With the pockets,

rebates, bevels and profiles which are encountered, the technique becomes one of profile milling (Fig. 2A and 2B). The ordinary profile mill is very old in its conception. A master form is used as a cam, around which a follower is made to trace the profile path. A cutting tool is carried on the same system as the follower, and as the profile path is traced, the cutting tool is made to follow a path which produces the component. Later developments of this principle have brought us the automatic copying machine, in which the path traced by the cutting tool is automatically controlled by a simple 10G profile template.

The tracing control may be achieved by a number of methods. The stylus is so controlled that it always seeks the template and, therefore, will profile around 360°. It may be servo-controlled from a manually operated handle or wheel. It may operate hydraulically so that the table motions follow its movements as a valve system controls hydraulic jacks. It may operate electrically as sensitive contacts close relays to control the electric motors which drive the table; 360° following may be achieved by magnetic attraction between the stylus and the template. There is an endless variety of solutions to the problem.

The tooling, however, is extremely easy to produce and simple in character. Most copying machines were not designed specifically for the aircraft industry and, therefore, do not possess spindle speeds which can be employed in cutting light alloys. We can use cutting speeds up to 10,000 ft. per minute and there are very few milling machines on the market which will approach this speed.

Routing Machines

With the advent of the powered router, however, we can achieve cutter speeds of 10,000 ft. per minute.

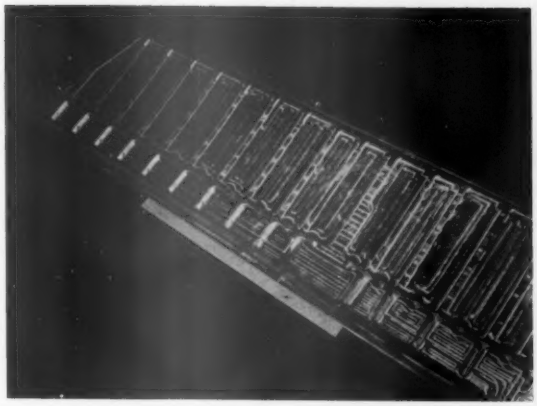


Fig. 2B. Section of integrally machined control surface skin. Stiffeners, spar boom, diaphragms and skin are in one piece.

and more if we need it. Using simple templates, we can control the machining of these large components on powered routers by normal hand routering methods. The templates are mounted directly on to the component, being bolted on to studs in material which is afterwards machined away; or the component may be located on a slotted table and the template supported over it by bolts or studs fitted in the slots. This simple set-up will serve for the rough machining of very large billets. The operator traces around the template using guide bushes engaging the template. Little effort is required by the operator, as the cutter is revolving as such high speeds. Very large cuts can be taken quite readily without any power assistance whatsoever.

Fig. 3.
Servo-hydraulic copy milling machine. The template is mounted overhead. The operator traces around the template using " dead man's handle " to deflect control stylus to contact template profile.

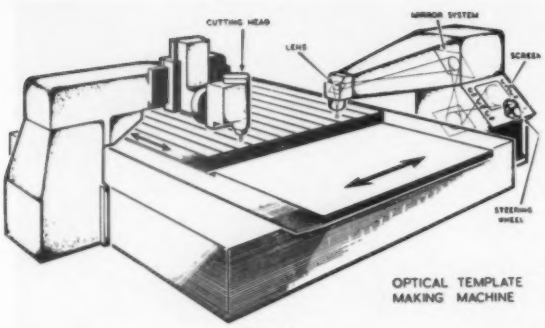


Fig. 4.

Extensions of this principle have given us the servo-operated copy milling machines in which the effort required by the operator in following a template is negligible (Fig. 3). There are quite a number of variations and improvements which can be made to high speed routing machines as this principle is developed, and I would go so far as to say that there is very little which cannot be done on the powered router where the machining of light alloys is concerned, even with components of extremely complex form.

The Manufacture of Templates

With the use of powered routers for machining of light alloy parts, the Hydrotels and expensive automatic copying machines which we may possess may now be used for the manufacture of parts in high tensile steel, which are now being demanded in many aircraft designs. The routers, however, use 10G mild steel templates to control the profile form and these templates must be manufactured. They are normally cut by hand from lofted plates and we should now apply ourselves to their production by automatic means. What is required is a machine which will translate the line drawn on a loft plate into motion of the cutting head, so that the template is automatically profiled (Fig. 4). This same machine could be used for the manufacture of form blocks, blanking tools, and the like, direct from a loft plate. There are several approaches to this problem of profile control from a loft plate. In one of these the image of the loft plate is projected by means of a lens and mirror system similar to that on an epidiascope, on to a screen at some convenient form of magnification. By means of a steering wheel, an operator can control the table motion so that the line projected on the screen is always in a fixed position relative to the cutting head. That is to say, there is on the screen in a fixed position, a disc representing the diameter of the cutter. The operator then brings the line projected on to the screen into contact with this disc, and is thus able to steer the table so that the required profile is traced out.

By varying the diameter of the master disc, templates may be cut, with allowance for flange widths, straight from a loft plate drawn to the heel line of a bend. The machine may also be used to make drill jigs and templates from a loft plate by making the images from the hole positions drawn on the loft, coincide with cross lines on the screen. The table is then locked and the workhead used to drill the required hole. Every hole on the loft plate may be traversed in turn and thus transferred to the drill plate. As the image is projected at 10 times full size the accuracy with which the loft may be reproduced is better than can be achieved by more normal methods.

This can also be done automatically by using a photo-electric cell to achieve the automatic following of a line drawn upon template material (Fig.5). Some time ago I described the means whereby a machine may be controlled by photo-electric cells which follow a line upon a drawing. The tracing head is now developed and its accuracy of following is well within .005". Mounted on a template machine, such as I describe, it would provide for the automatic profiling of templates.

Lofting by Co-ordinate Setting Machine

Let us now carry this idea a stage further. Having made the manufacture of our templates an automatic process, can we not also simplify the lofting procedure? It will be necessary to design and employ simple co-ordinate setting machines for laying out those plates. There are such machines on the market at the present moment. I shall presently describe a co-ordinate drilling machine, which could be applied to the setting of loft ordinates. In the place of the drilling spindle, a sensitive marking device or a solenoid operated punch would mark out the required ordinates on the loft plate. This would dispense with rules, trammels and dividers.

Drilling by Co-ordinate Setting Machine

The next problem is the provision of jigs for the drilling of the numerous holes which are required in the machined items. As these machined items can be very large, the jigs involved can be extremely complicated and expensive. The question here is, is it necessary to provide drill jigs at all? A co-ordinate setting machine in which a drill head is brought to any desired position over a table under accurate control is what is required.

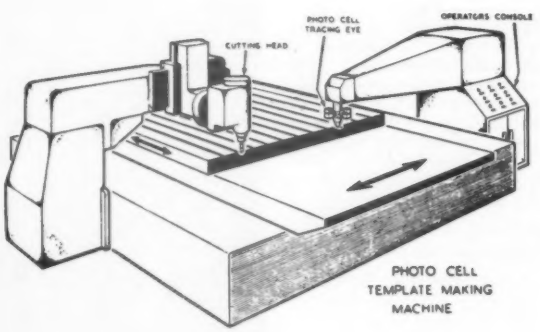


Fig. 5.

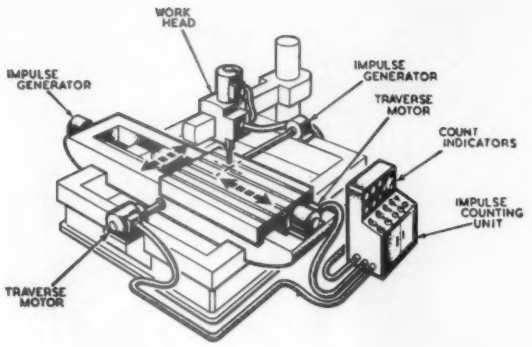
There is a jig boring machine on the market in which the position of the head can be set quite simply. The co-ordinate measurements are set up on dials, and when the machine is started, it will automatically move to the required position. With the addition of another console, the co-ordinate positions of a number of holes can be set-up in programmed sequence, so that the machine will drill one after another, a number of holes which are automatically positioned, and it will continue to carry out that sequence indefinitely. The setting merely involves the insertion of plugs into a peg board arrangement. Such a machine would considerably reduce the tooling involved, and the time taken to manufacture the drill jigs.

The machine described is expensive, but a much more simple co-ordinate setting machine could be manufactured using a table moving in the two translatory motions under the control of accurately made lead screws (Fig. 6). The lead screws would each be made to drive a rotor with holes or slots cut into it. The rotor would be geared to the lead screw so that a hole would pass a certain point each time the table moved through one thousandth of an inch. By means of a light source and a photo-electric cell an electrical impulse is transmitted each time. It is possible to arrange the sequence of the electrical impulses so that information may be conveyed to the counting mechanism to indicate whether the table is advancing or retreating from a datum point. An electronic counter can be made to register the number of impulses on a series of dials, so that the exact distance through which the lead screw has moved can be read off easily as ordinates. The counter will add or subtract according to whether the table is moving towards or away from the chosen datum and thus ordinates can be read directly. Thus under control of the operator the machine could be brought to a desired setting quickly and easily.

It is but a simple step from this to recording the ordinate positions on a punched tape, in order to get automatic programmed sequence drilling. Such a machine will move to a desired position by balancing the number of impulses transmitted by the photo-cell against the reference provided by the tape and bringing the machine to a standstill when exact balance has been achieved, and thus fixing a co-ordinate point. If all the motions are recorded in sequence upon a tape, then the machine will repeat the same drilling programme over and over again. It will now be seen that tooling has been entirely eliminated by the substitution of a punched tape. Such a form of machine control is readily modified, as circumstances require, so that changes in design can be brought into production very quickly.

Machining by Chemical Means

Another promising field is chemical machining, in which the chemical erosion of the workpiece is brought about under control (Fig. 7). Acid or alkaline etchant is used to remove the material in order to attain a desired shape. The process is being developed upon light alloys at the moment. Some simple method of masking is required to protect the surfaces



CO-ORDINATE SETTING & DRILLING MACHINE.

Fig. 6.

which do not require to be worked upon. As this process is only in its infancy, we shall see it developed until it replaces some of the present forms of machining, with the elimination of tooling.

The etching resistant masking materials can be sprayed on over a simple template to protect certain areas of the workpiece, or they may be applied in the form of tape, or by photographic or lithographic means. Curved and complicated shapes can be formed prior to the etching operation, with the elimination of many of the difficulties experienced today in forming materials after they have been machined in the flat. The machine tools are now reduced to simple tanks containing the chemical etchants, washing and drying materials, etc. The process is capable of very close control, and surprising accuracy in the depth of etch can be achieved, but an intensive research programme is needed to bring the process to its maximum productivity.

Machining by Spark Erosion

The machining of light alloys is not a difficult process as the material cuts so readily, but the

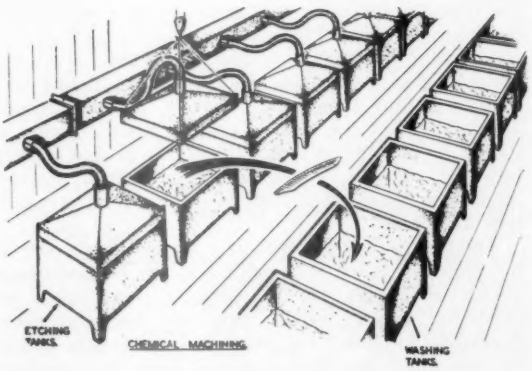


Fig. 7.

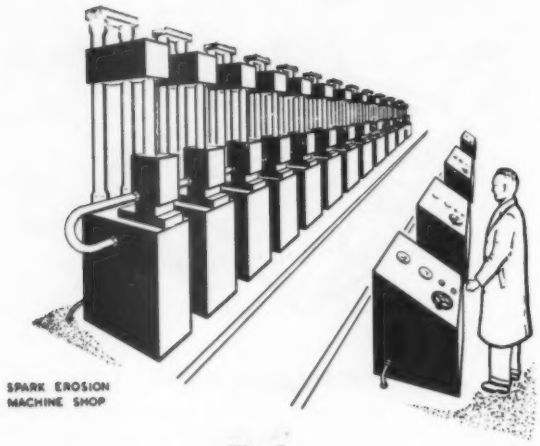


Fig. 8.

machining of large components from high tensile steels of the order of 90 or 100 tons is an entirely different matter. Such machining is laborious and time-consuming, and a good deal of research and energy must be directed towards the perfection of machining methods for these items. Much can, of course, be done by perfecting cutting steels and the use of automatically controlled machine tools, but I look forward to entirely new cutting methods.

It is only recently that spark machining has been introduced and the process cannot, therefore, be said to be in an advanced stage of development. The controlled electrical disintegration of metals is a very promising method for the production of parts from hard materials. It entirely eliminates cutter troubles, as only simple electrodes made from soft conductors are used to direct the cutting energy. If the whole of the electric energy which is used can be directed towards the shaping of the material, we may yet arrive at the most efficient method of forming complicated shapes.

The normal machine tool for the cutting of high tensile steels must necessarily be of heavy and rigid construction, but only comparatively light and simple machines are needed for spark machining (Fig. 8). A good deal of the energy put into the normal machining methods goes in heat and friction as the cutting tool is forced into the work, whereas by the proper development of the electric disintegration process, it should be possible to direct the whole of that energy into the removal of the material, with a marked increase in the speed of cutting. The process is rather slow at present.

The theory of spark erosion is somewhat obscure at the moment, but it is thought that the instantaneous release of energy at the sparking point melts or vaporises a very small part of the workpiece. According to theory, the wear on the electrode should be very much less than it is and when this problem is also solved, the production of electrodes by pressing, coining, sintering or casting will be an easy matter.

Electro erosion machines require very little attention and can be very accurately controlled. One operator can attend a whole bank of them, so that the amount of labour required is small. Much more thought, energy and research must be applied to this process and with its perfection, the spark erosion machine will take its place in the machine shop alongside any other cutting tool.

Improving Production of Sheet Metal Components

We have not yet touched upon the production of sheet metal items. Surely it is not beyond our capabilities to devise entirely new and revolutionary methods for producing these items. Take, for example, a small bracket which needs blanking, drilling and forming. Generally speaking, we are today using the same kind of tooling that we used a quarter of a century ago, unless the quantities are very large when it becomes economic to use blanking, piercing and forming tools. I am looking for an automatic way of producing this type of component directly from a drawing or a loft plate, without the necessity for tooling. Perhaps someone has some ideas of the way in which research can be directed to bring about this desired ideal. Remember, what we are seeking is the elimination of tooling as we know it today, so that the part must be produced from a pattern or a drawing.

Production of Pipes

Similar attention should be directed to the methods of forming aircraft pipes. We are gradually replacing the coppersmith with mandrel bending machines and similar processes, but this cannot be done with all the pipes that are encountered on aircraft. To be successfully bent on a mandrel bending machine, a pipe must have standard radii in the bends and the bends cannot be too close together or of complicated form. Unfortunately, the tightness of some of the pipe runs in aircraft do not allow us to run the pipes as we would desire and non-standard piping runs result.

Of course, there are other methods of forming pipes than employing a coppersmith, e.g., by using

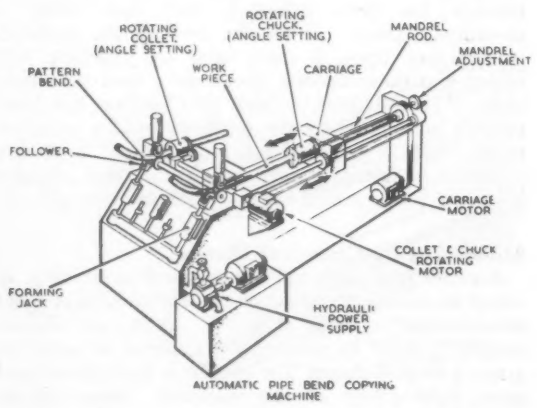


Fig. 9.

hydraulic forming in a die and so on. I suggest that it is possible to design a machine which will produce a pipe automatically by using a master pipe to control the machine movements. Such a machine is illustrated in Fig. 9.

Tubing is forced through a die or between rollers rather as an extrusion is forced through a die. By changing the axial disposition of the die or by advancing a third roll, the tubing will become bent as it extrudes. Control of this function will be brought about by a master pipe mounted on the machine. Hydraulic feelers will trace over the pipe to operate the jacks controlling the die movement. Feed back from the formed pipe will enable the machine to compare it with the master and carry out continuous correction. Where the bends are not all in one plane, pegs welded to the master pipe will trigger the rotation of the whole system until the bend is in the correct position for bending.

I would not consider the use of cams or templates to control the machine, as these necessarily involve the production of tooling, and increase the time in setting up the machine. It also complicates the task of introducing modifications to the run of any pipe. With the advent of such a machine the necessity for tooling in the production of pipes would be entirely eliminated.

Of course, the master pipe may be described numerically as so many inches of parallel portion, a bend of such a radius for so many degrees, followed by another bend of another radius to be disposed at such and such an angle to the first and so on. This information could then be punched on tape and the movements of slide, die and collet rotation controlled electronically. Think of the saving in time, in tooling and in the incorporation of modifications. The machine would be easy to set, merely requiring the correct die and collet, and the insertion of a paper tape. There would be no need for form blocks or jig boards, except where one pipe has to be welded or brazed to another.

Research

You will see that throughout the course of my talk I have been stressing the need for the cutting down or even the elimination of tooling. We can go a long way towards this at the present moment, but many more ideas are needed and much more money spent in research. There is no room for us to be complacent about any successes. Each one must spur us to fresh developments. With the elimination of complicated tooling, we shall be much more flexible, and the time taken to get into production will be considerably reduced.

To do this, every method of production we use at the present time must be critically examined to see whether there is another and better way of performing the function. No matter if we try ideas which seem at first sight to be impracticable and even slightly mad. No matter if we fail time and again. If only one or two of these ideas prove successful, as they must, and do, then these will more than recompense us for the failures.

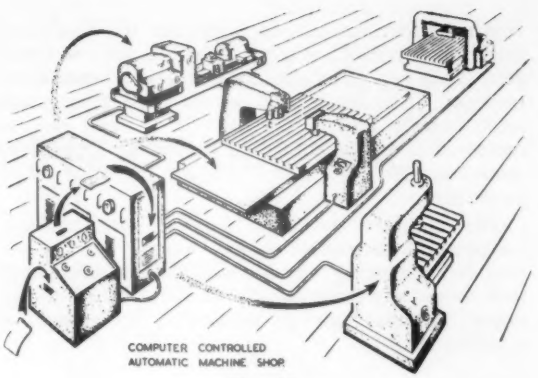


Fig. 10.

I would judge a development research section as much by its failures as by its successes. If there are too few failures, then the ideas they have been pursuing are not sufficiently novel.

The Automatic Factory

Of course, the final goal is the automatic factory. This is already in sight. I don't assert that it will ever be possible to make complicated assemblies by automatic means, that is to say, to assemble a motor car engine or an aircraft engine or an airframe from its various component parts, entirely without human intervention, but assembly is not a difficult procedure once the parts are available. It is towards the manufacture of the detail parts that the idea of automatic production should be directed,

As I said earlier, if we could arrange things so that we had a draughtsman, a machine and a stores bin, in that order, where the draughtsman produces the information which is fed into the machine, and the machine produces the part from that information, whence it is conveyed direct to the store, we should have the ideal set-up (Fig. 1). We see signs that there is a general trend towards this idea, with an improvement in tooling methods. Much complicated machining can now be carried out with the use of very simple templates as the only tooling which is required.

Within a very short time it will be possible to manufacture components directly from a loft plate without the necessity for tooling, and perhaps eventually from numerical information fed into an electronically controlled machine tool. Although the components produced by the new techniques will be of greater complexity, they will be fewer in number. This will mean that we can reduce the effort now put into the progressing of a large number of small bits and pieces; reduce the amount of space covered by our stores; cut down the assembly times, reduce the total number of tools and eliminate the use of large assembly jigs.

The automatic factory will require machine tools which can carry out complicated machining operations without human intervention (Fig. 10). Consider the functions which the human operator performs. He reads the drawing and positions the cutting tool according to his interpretation of the designer's intent.

Having taken his cut, he measures the work and resets or adjusts his cut according to the results he gets. Thus to a given stimulus he makes a conditioned response. A machine can do the same thing much more quickly and accurately. If a thing can be measured it can be controlled automatically and the same response given every time for the same set of conditions.

The measurement may be of size, position, temperature, hardness, colour, weight and so on. Automatic gauging of any combination of various such measurements is already well established and in many instances giving automatic correction of machine settings.

The Principles of Automation

Fundamentally, the automatic control of machines may be divided into three principles. One is operation by cause and effect where a given stimulus gives a conditioned response. In this type of control a feedback is arranged from the cutting tool, whereby the position of the cutting head is compared with a master form by mechanical, hydraulic or electrical means. Any discrepancy between where the tool is and where it should be is corrected by the machine. Since this machine is essentially a positional error device, i.e., there must be a slight discrepancy in order that the machine can operate, extremely close dimensional form is difficult to achieve. Extreme sensitivity may make the machine "hunt" around the optimum position and so some measure of "damping" is introduced, which reduces the accuracy. An example of this kind of control is the "homing" projectile which "locks on" to a target and, no matter what evasive action is taken, corrects its bearing to suit.

With machine tools a master pattern is required to enable the cutting operations to "lock on". This may take the form of a template, a master part, a drawing and so on. With this type of control then, the machine follows a pattern, comparing and correcting as the cut proceeds.

The second is a machine with a memory. Here, control is achieved by means of information stored on a tape or other convenient form. The movements of the machine slides and cutting heads are recorded on the tape during the manufacture of an initial workpiece. The tape is then passed over an electrical pick-up and the impulses it receives are used to reverse the original procedure of recording, that is, to control the electric motors operating the various functions of the machine to make it perform the operations carried out in the manufacture of the original workpiece. The signals from the tape are amplified and through servo-mechanisms drive the machine slides in synchronisation with the record on the tape. The record may be played over and over to make the machine repeat the production cycle as many times as required. In contrast to the first type of machine, which requires a master part, this is a machine with a memory. It is complete in itself.

Here we have the essence of simple tooling. A tape may be easily stored and setting up the machine is easy. Modifications may be readily and quickly stored on the tape, or the record may be wiped clean electrically and the tape used over again for a fresh programme. Machines are now being built in which a programme of work sufficient to carry out all the intricate machining on an aircraft rib forging or fuselage frame or wing skin is stored on such a tape. No other tooling is required, except the cutting tools and holding fixtures.

The tape may be recorded from original machine motions or it may be made synthetically. There are developments which will enable numerical information in the form of ordinates and equations governing curves to be fed into a computer, the signals from which are then recorded on tape.

Thirdly, a machine tool may be controlled directly by what is popularly described as an electronic brain. Developments in this country are now proceeding whereby numerical information is fed into an electronic calculator which continuously works out and controls the position of the machine slides and cutting head. We cannot foresee what developments may arise from this line of approach, but it may well be that a single computer may control a large number of machines. The speed of response is so great that the information is instantly available. Here we have the beginnings of a machine possessing executive functions.

Man is an imperfect machine. There are definite physical limitations to his output and speed of response which may well make him incapable of operating future machine tools. Already the speeds of aircraft are so advanced that the actual guiding of the aircraft will be taken out of his control after take-off, and carried out by electronic means.

Where the human being excels over the machine is in his ability to take executive action, in being able to think ahead; in creative thought. No machine can do these things, although certain laboratory machines can work out the answer to a problem by trial and error and store the information. When a similar problem comes up again, it then recalls the previous experience and makes the correct response to the external stimulus. There is a machine built which none can beat at the game of noughts and crosses.

Conclusion

Who can tell, therefore, what the future may hold ? We are rapidly approaching an age of unlimited nuclear power supply and articles may yet be built up from their constituent molecules, instead of being laboriously and wastefully cut from blocks of metal by methods which we tend to regard as incapable of improvement. I have in mind a process similar to electrolytic plating, rather than one in which the ultimate particles of matter are tailored into raw materials. This will no doubt come later, as we exhaust our stocks of raw materials. It *must* come.

It is our responsibility, as production engineers, to devise the most efficient and economic techniques for producing the ever-increasing quantity and variety of consumer goods demanded by a dynamic society. By so doing, we not only increase the world's store of wealth, but contribute significantly to the reduction of human drudgery.

REPORT OF THE MEETING OF COUNCIL

Thursday, 28th April, 1955.

THE final Council Meeting of the 1954/55 Session was held at 10 Chesterfield Street, London, W.1, on Thursday, 28th April, 1955. The meeting, which was presided over by the Chairman of Council, Mr. G. R. Pryor, was attended by 29 members, and the following were present by invitation: Mr. J. L. Townend, Hon. Secretary of the Yorkshire Section, Acting Hon. Secretary of the Yorkshire Graduate Section, and Hon. Treasurer of the East and West Ridings Region; Mr. L. Rutter, Chairman of the Coventry Graduate Section; and Mr. T. B. Wilcox, Chairman of the Birmingham Graduate Section.

Election of Principal Officers, 1955/56

The Council unanimously approved the Finance and General Purposes Committee's recommendation that the following be elected:-

President, Sir Leonard Lord, K.B.E.

Chairman of Council, Mr. G. R. Pryor.

Vice-Chairman of Council, Mr. H. G. Gregory.

In making this recommendation to Council, Major-General Appleyard said he was sure that Council would wish him to add their thanks and admiration for the way in which Mr. Pryor and Mr. Gregory had carried out their onerous duties during the past year.

Finance

It was reported by the Finance and General Purposes Committee that the budget was being maintained both as to Income and Expenditure.

National Conference, 1955

The Secretary reported that the Margate Conference on "The Automatic Factory—What Does It Mean?" was attracting a considerable amount of attention both at home and abroad. More than 700 applications to attend had already been received.

The President had held a Press Conference in March to introduce the Conference, which had been attended by nearly 100 members of the lay and technical press.

From present indications it would appear that the Institution could look forward to a very impressive and successful Conference.

Production Exhibition and Conference, 1956

It was announced that the Second Production Exhibition and Conference would take place from 23rd to 31st May, 1956, in the Grand Hall, Olympia, London. The President had already invited a number of members to form an advisory committee.

Cornwall Section Conference

The Secretary reported that the Conference on "Compressed Air As An Aid to Productivity", arranged by the Cornwall Section and held at Camborne on 13th and 14th April, had been highly successful. There was an attendance of over 100, many of whom had journeyed to Camborne from other parts of the country. In conjunction with the Conference, the Cornwall Section Committee had organised a small exhibition of examples of pneumatic equipment.

The Council congratulated the Cornwall Section on the success of this venture. (A report of the Conference appears on pages 395/396 of this Journal.)

George Bray Memorial Lecture, 1954

The arrangements for this Lecture, which was very well attended, were made by the North West Regional Committee. The speaker, Mr. Robert Douglas, M.B.E., M.I.Prod.E., chose as his subject, "Engineering and Production Aspects of Synthetic Fibre Manufacture", which fully met the terms of reference for this important Paper, and which was extremely well received. (A full report of this meeting will appear in the July issue of the Journal.)

Specialist Divisions

The Sub-Committee set up by the Finance and General Purposes Committee to examine the possibility of establishing specialist divisions within the Institution had not yet concluded their deliberations.

The Journal

It was reported by the Editorial Committee that a new contract had been negotiated with the Institution's Advertising Agents and was now being drawn up. This new contract would give the Institution greatly improved terms, in that it would run for a fixed number of years, with no renewal rights, and the rate of commission had been reduced from 22½% to 17½%. The new contract would come into force on 1st July, 1955.

The Council expressed appreciation of the negotiations carried out by the Advertising Sub-Committee.

It was moved by Mr. A. L. Stuchbery, and seconded by Mr. J. E. Hill, that the Council, having heard the report of the Sub-Committee, approved the general terms of the new contract and authorised the use of the Institution's seal when the contract had been drawn up by the Institution's solicitors.

In reply to Mr. Stuchbery, the Chairman of Council said that the cost of producing the Journal was under close control by the Editorial Committee, and was constantly under review.

Institution Papers

It was reported by the Papers Committee that the 1955 Viscount Nuffield Paper would be given by Dr. G. H. Daniel, Head of the Statistics Branch of the Ministry of Fuel and Power.

The Committee were also taking active steps to promote papers for publication in addition to those submitted by Sections, as the increasing size of the Journal made it imperative that a constant supply of high quality material be maintained. The Committee felt that there was much latent talent in the Institution in this direction, and urged members to give serious consideration to the question of writing papers for publication, as a great deal of valuable material could be made available in this way.

New Headquarters Appeal Fund

It was reported by the Finance and General Purposes Committee that the Fund now stood at £16,633, and a small number of donations were still being received.

Council Elections

The ballot to decide the eight elected Members and one Associate Member to retire from Council for the year 1955/56 had been made by the Vice-Chairman of Council, Mr. H. G. Gregory, in the presence of the Finance and General Purposes Committee. As a result, the names of those elected members of Council due to retire were as follows :-

A. J. Aiers; H. W. Bowen, O.B.E.; A. G. Clark; F. J. Everest; R. S. Hind; A. L. Stuchbery; C. Timms; R. H. S. Turner. Associate Member :- B. E. Stokes.

Loughborough College Students Section

An Institution Students Section had been formed at Loughborough College. The Finance and General Purposes Committee had agreed that the Institution should support this Section and pay any legitimate expenses.

It was made clear that the centre was not just for technology students of the College, but to cover further education and any other students in the Loughborough area, which was a growing industrial centre.

Qualifications for Membership

It was reported by the Membership Committee that they had been engaged on revision of the confidential booklet on qualifications for membership, and were at present considering draft revisions of certain sections. When revision was complete, the booklet would be reissued to Sections and, in the meantime, intermediate revisions would be circulated.

Canada — Courses in Production Engineering

It was reported by the Secretary that following the approach made last year to the Ryerson Institute of Technology in Toronto, to assist Canadian members or prospective members in pursuing courses which would enable them to obtain the necessary qualifications for corporate members, information had now been received that the Canadian Section and the Ryerson Institute had held joint meetings. As a result, the Institute had arranged courses which the Section considered should provide for each part of the A.M. examination. Furthermore, the Institute proposed that its own Diploma examination might be considered for exemption purposes. These matters had been referred to the Education Committee.

Sydney Section Scholarship

It was reported by the Education Committee that the Sydney Section of the Institution were in the process of raising £5,000 to establish a Scholarship on the lines of the Schofield Travel Scholarship.

Summer School

The Chairman of the Education Committee reminded the Council that the 1955 Summer School would be held at Ashorne Hill, Leamington Spa, from 24th/28th August. The theme would deal with anticipated developments in industry and education in relation to future requirements, particularly in management.

The principal lecturers were: Mr. G. Bosworth, Chief of Technical and Personnel Administration, English Electric Co. Ltd.; Principal Venables, of the Royal Technical College, Salford; and Mr. A. P. Oppenheimer, Production and Costing Department of Tube Investments (Group Services) Ltd.

Research

The following reports were made on behalf of the Sub-Committees of the Research Committee :-

Materials Handling. The Sub-Committee had been mainly concerned with the proposed formation of a Materials Handling Division. They had also considered the supply of case studies and were seeking further studies with the object of making a more detailed report than any of those previously published.

Materials Utilisation. Although rarely meeting formally, the Sub-Committee were making good progress with the work of correlating and commenting on the case studies at their disposal.

Production Control. The final report of the Joint Committee on the Measurement of Productivity, in which this Sub-Committee had taken a leading part, had now gone forward for printing.

Sources of Information. The Sub-Committee had raised with the Editorial Committee the question of publishing in the Journal articles on the Reports of the Research Committee, immediately prior to the publication of such Reports. This had been agreed in principle.

The Sub-Committee had invited to their next meeting the research workers at the University of Edinburgh who were investigating the inspection process in industry. A report was still awaited on the investigations at Southampton into the impact of American-financed companies on British industry.

Standards

It was reported that the Committee were organising, in co-operation with the British Standards Institution, a Conference of Standards Engineers, which would take place on 4th May at British Standards House. This would be an informal conference and subjects to be discussed included the coding of standards, the issue of loose-leaf data sheets, and the use of British Standards.

The Council approved the Finance and General Purposes Committee's recommendation that the terms of reference of the Standards Committee should be amended to include the following :-

"To recommend to the Council such other action as may be deemed expedient in promoting standardisation."

Hazleton Memorial Library

The Library Committee reported with regret that they had lost the services of Mr. E. Fedder, who had now taken up an appointment in Cheltenham.

The Committee were pleased to report that an increasing number of members were using the Library. Due to the steadily improving stock, and the acquirement of several copies of the more popular volumes, it was now possible to meet almost any request with the minimum of delay.

Corresponding Member in Iraq

The Council approved the recommendation of the Finance and General Purposes Committee that Mr. W. G. Rooke, A.M.I.Prod.E., of the Iraqi State Railways, be appointed Corresponding Member in Iraq.

Liaison with Sections Outside the U.K.

Calcutta and Bombay. On the recommendation of Mr. J. D. Scaife, it was agreed that the Finance and General Purposes Committee should consider the possibility of sending a small deputation of Institution members to India, to discuss at Government level how the Institution could best assist in raising the standard of technological education in India.

Sydney. It was reported that the Sydney Section were arranging a two-day Conference in July, 1955, to coincide with a Machine Tool Exhibition. The title of the Conference was "Productivity and the Machine Tool". The Section had arranged with The Australian Institute of Management to provide management subjects on the first day, dealing with automation, operations research and executive development, and on the second day it was hoped to have speakers dealing with technical aspects of the modern factory, in particular, transfer machines and their influence on productivity.

Visitors. Among visitors from overseas to Head Office were Mr. C. W. Pearson, Mr. N. L. Esserman and Mr. T. F. Ring, all of the Sydney Section; Mr. H. le Cheminant, a Past President of the Australian Council; and Mr. E. H. Y. Burden, Past President of the Bombay Section. The two last-named would be attending the Margate Conference.

Obituary

The Council recorded with deep regret the deaths of the following members :-

Members : D. W. Russell; W. Ogilvie; N. J. Walton; A. Scrivener; A. E. Farrer.

Associate Members : W. G. Cornell; C. E. Curzons; H. T. Marshall.

Affiliate Representative : M. Middlebrook.

Date and Place of Next Meeting

It was agreed that the next Meeting of Council would be held on 21st July, 1955, at 11 a.m., at 10 Chesterfield Street, London, W.1.

ELECTIONS AND TRANSFERS

28th April, 1955.

The following were elected to membership by Council:

BIRMINGHAM SECTION

AS MEMBER
J. I. Yates.
AS ASSOCIATE MEMBERS
J. Birtwhistle, A. Downes.
AS GRADUATES
A. E. Cooper, H. G. Poole.
AS STUDENTS
R. N. Britton, D. Hickman, S. J. Samuels, G. B. Whitmarsh.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
E. J. Huffer.
FROM GRADUATES TO ASSOCIATE MEMBERS
J. A. Cleal, J. E. Townsend.
FROM STUDENTS TO GRADUATES
R. B. Bristoll, S. A. Pett.

BOMBAY SECTION

AS ASSOCIATE
F. X. A. D'Souza.
AS STUDENT
S. K. Bhattacharyya.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
R. N. Rai.

CALCUTTA SECTION

AS MEMBER
K. K. Framji
AS GRADUATES
S. B. Gupta, J. S. Murdia.
AS STUDENTS
A. De, K. Ghatak, S. S. Marwaha, M. K. McGregor
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
P. S. McCaig.

CANADA SECTION

AS GRADUATE
H. U. R. Siddiqi.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
T. P. Keenan.

CORNWALL SECTION

AS STUDENT
J. C. Newcombe.

COVENTRY SECTION

AS MEMBER
W. G. Rootes.
AS GRADUATES
H. W. Beck, R. G. Bullock, W. Hickling, D. L. Richards.
AS STUDENTS
R. W. Gambling, R. H. Gloster, R. W. Stuchbery.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
N. Asquith, S. Haywood, G. W. Pitt.

DERBY SECTION

AS MEMBER
H. L. Barman.
AS GRADUATES
G. A. Parnham, A. Salt.

TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
D. R. H. Webster.

DONCASTER SECTION

AS STUDENT
L. Waller.

EASTERN COUNTIES SECTION

TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
F. T. Dyer.

GLASGOW SECTION

AS MEMBERS
J. Campbell, J. Drummond, J. H. Parker.
AS GRADUATES
J. H. Carslaw, J. E. Mitchell.
TRANSFER
FROM STUDENT TO GRADUATE
S. F. Pearson.

GLOUCESTER SECTION

AS STUDENT
M. O. Hickman

HALIFAX SECTION

AS STUDENTS
F. Jones, D. W. Watkinson
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
J. W. Dunford

LEICESTER SECTION

AS GRADUATE
P. K. Bedi
AS STUDENT
R. W. J. Hutton

LINCOLN SECTION

AS STUDENTS
P. J. Jordon, F. B. Matthewman.
TRANSFERS
FROM STUDENTS TO GRADUATES
G. F. Howden, A. E. Maw.

LONDON SECTION

AS MEMBERS
F. P. Bowyer, Sir F. J. E. Brake, T. Ratcliffe.
AS GRADUATES
R. D. Belcher, H. Bibring, L. C. Hodges, M. F. Knight, F. R. Norris, C. Sanders, P. T. Sylvester.
AS STUDENTS
B. E. Bayley, J. U. Grubb, C. E. Leeder, B. J. Pyman, G. B. Wilson.
NEW AFFILIATED FIRMS
Diamond H Switches, Ltd.
J. Thompson & Sons (Gears), Ltd.
NEW AFFILIATED REPRESENTATIVES
P. A. V. Rudd, R. C. Carwood, J. A. Thomson, F. Jolly.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
A. T. Coote, L. G. Humble, H. A. L. Logan.
FROM GRADUATES TO ASSOCIATE MEMBERS
B. W. Charman, W. P. Collier, R. J. Ford, W. R. Hall, R. Harris, D. Hitchings, A. Measures, K. A. Pratt, A. F. W. Smith, R. A. Ward, J. C. Martin.
FROM STUDENTS TO GRADUATES
R. J. Biggs, G. A. Deague, P. J. Hobson, P. J. Lewis, G. J. Stanbra.

LUTON SECTION

TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
N. L. E. King.
FROM STUDENTS TO GRADUATES
I. L. Johnson, C. J. Norbury.

MANCHESTER SECTION

AS ASSOCIATE MEMBER
K. D. Aldwinckle.
AS GRADUATES
R. H. Plumbly, J. Proctor.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
H. Balmer, J. J. Dodgson, F. Koenigsberger.

MELBOURNE SECTION

AS MEMBERS
R. Chaney, R. R. Clark, F. H. Kreide.
AS GRADUATE
J. W. Vosti.
AS STUDENTS
D. C. Lewis, F. A. Roberts, J. P. Ulbrick.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
R. W. Deutsher, N. W. Hodgson.
FROM STUDENTS TO GRADUATES
R. E. Driscoll, P. M. Ferguson.
NEW AFFILIATED REPRESENTATIVES
H. W. Pickett, K. C. Lang.
H. A. Blake, H. M. Cooper, M. J. Allen.
NEW AFFILIATED FIRMS
Dept. of Supply (Commonwealth Department).
Alfred Herbert (Australasia) Pty. Limited.

NEW ZEALAND SECTION

AS MEMBER
H. S. Weston.

NORTH EASTERN SECTION

AS GRADUATE
N. A. Forster
AS STUDENTS
C. Hutchinson, K. B. Khanna.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
A. M. Hounam, C. Plews, D. F. H. Rushton.
FROM STUDENT TO GRADUATE
F. J. Webb.

NORTHERN IRELAND SECTION

AS MEMBER
R. E. Harvey
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
J. L. Fromson, G. H. Moore, J. H. Place, K. Teale, W. G. Wyman.

NORWICH SECTION

AS STUDENT
E. B. Middleton.

NOTTINGHAM SECTION

AS STUDENTS
J. C. Covell, A. E. Lucas, R. H. Philipson, R. F. Wheelhouse.

OXFORD SECTION

AS STUDENTS
D. E. Milward, L. C. Pumfrey.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
D. R. B. Ripp.

READING SECTION

TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
H. Gurvick.

ROCHESTER SECTION

AS ASSOCIATE MEMBER
G. Sharp.
TRANSFERS
FROM STUDENT TO ASSOCIATE MEMBER
R. P. Bernard
FROM STUDENT TO GRADUATE
B. E. Thornby.

SOUTH AFRICA SECTION

AS ASSOCIATE MEMBER
D. J. M. Douglas.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
C. Archer, S. E. Parsons.
FROM GRADUATE TO ASSOCIATE MEMBER
B. J. Bluhm.
FROM STUDENT TO GRADUATE
J. M. Moseley.

SOUTH WALES SECTION

TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
J. Parry-Jones.
FROM STUDENT TO GRADUATE
H. M. Williams.

SOUTHERN SECTION

AS GRADUATE
V. N. Thurston.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
C. J. Pearce.

SYDNEY SECTION

AS GRADUATES
K. T. Bicknell, A. Brack, S. J. O'Keefe.
AS STUDENT
W. M. Ward.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
K. W. Jones.

TEESIDE SECTION

TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
E. C. Nicholson.

WEST WALES SECTION

TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
W. Williams.

WESTERN SECTION

AS MEMBERS
W. Strachen, P. Wills.
AS STUDENTS
K. G. Lane, J. T. Whitney.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
A. H. Manser.
FROM STUDENT TO GRADUATE
R. Hutton.

WOLVERHAMPTON SECTION

AS GRADUATES
K. V. Barber, R. F. Brookes, J. A. Nicholls, W. A. J. Wilson.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
R. H. J. Tyson.
FROM STUDENT TO GRADUATE
K. A. Cooper

WORCESTER SECTION

AS GRADUATE
D. J. Hunt.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
N. T. Meek.

YORKSHIRE SECTION

AS GRADUATE
D. Pickles.
AS STUDENTS
J. Lever, P. Stewart.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
R. Bailey, F. Varo.
FROM STUDENT TO GRADUATE
J. E. Thomis.

NO SECTION

AS MEMBER
H. Abboudi.
AS ASSOCIATE
A. E. Scheurkogel.
AS GRADUATE
L. A. Yardeni.

EXTRACTS FROM LOCAL SECTION REPORTS

Presented to Council, 28th April, 1955.

EASTERN REGION

Eastern Counties

At the first lecture meeting of the New Year, the Section was honoured by a visit from the President of the Institution, Sir Walter Puckey, whose Paper on management started a lively discussion among those present.

The February lecture was given jointly by Mr. J. J. Stordy and Mr. W. G. J. Appleton, who read a Paper on "Industrial Finishing Technique and Practice — Paints and Organic Coatings". This Paper was well illustrated by slides, and covered both the pre-treatment and painting processes employed in industry.

The Annual General Meeting of the Section, at which Officers and Committee Members were elected for the coming year, was held in March. Owing to the illness of the speakers, only one Paper was given after the A.G.M. instead of the three as originally planned. The Paper was given by representatives of a local firm on the subject of quality control in the foundry. Two films were shown in place of the other Papers, and this alternative proved to be popular.

EAST AND WEST RIDINGS REGION

Doncaster

The Section have just completed the lecture programme for the Session 1954 - 55 and it can be reported that, on the whole, attendance at these has been very good. The Committee are now arranging the 1955 - 56 lecture programme.

Applications for membership continue to come in at a steady rate, and it is hoped that by the end of the Chairman's term of office the membership will have about doubled. The Committee report with pleasure that a Paper given by Committee Member T. B. Maddison on "Production Methods in Railway Workshops" during October of last year is to be published in the Journal (see this issue).

The joint meeting with the Doncaster Productivity Committee to hear Dr. Patrick deliver his Paper on "The Manufacture of Plate Glass" was well attended and a very lively discussion followed.

Halifax

No lecture meeting was held in January. In February there was a record attendance to hear the Section Chairman, Mr. F. J. Everest, deal with the subject of "Productivity in Worm Gear Unit Manufacture" in an excellent manner. Heavy snow affected the attendance at the March meeting when Professor T. U. Matthew presented his lecture on "Work Measurement Research", but those who did brave the elements were amply repaid by another first-class meeting.

Gratitude is felt for the excellent lecturers who served throughout the Session, as due to the heavy demands upon the time of the experts, together with more frequent foreign travel, it is increasingly difficult to build up a Section Programme.

At the Annual General Meeting, Mr. F. J. Everest was re-elected Chairman, and Mr. W. A. Hannaby, Vice-Chairman.

Section represenation at Regional Committee Meetings has been 100% and Section members are being encouraged to participate in Regional activities.

Sheffield

The Section completed its lecture programme with a Paper entitled "The Practical Application of Production Engineering Research" by Dr. D. F. Galloway. This was a Regional Meeting under the Chairmanship of Mr. J. E. Hill, who afterwards entertained the Speaker and several guests to dinner.

In February an informal discussion on "Work Study" resulted in an interesting and lively debate.

The Section Committee arrangements for next year's lecture programme are well in hand, and although there is a very wide field to cover in the area, lectures and speakers have already been decided, namely: "Copying Devices for Machine Tools"; "Fabrication as Applied to Steelworks Plant"; "Bar Mills"; and "Health in Industry".

The Section Annual Dinner for 1955 has been arranged to take place on October 10th.

Yorkshire

The Annual General Meeting was held in March when Mr. D. H. Turnbull was re-elected Chairman for the next Session. Messrs. F. T. Nurrish, G. Hayes, R. Shilton and J. M. Wilson, retiring members of the Committee were re-elected, and Mr. J. L. Townend was re-elected Secretary. The meeting was reasonably well attended, and the thanks of the members were expressed to the Chairman, Committee and Secretary for their work during the past Session.

After the A.G.M. the members listened to a very fascinating talk on the "History of Radar" given by Mr. C. O. Taylor, M.B.E., and it was agreed by all present that it was one of the best talks which had been given to the Section.

MIDLANDS REGION

Coventry

"The Production of Precision Involute Gears", the February lecture by Committee Member Mr. W. H. T. Golding, attracted nearly 100 members and visitors. Mr. Golding introduced a rather novel aspect to the subject — Precision Production by Prediction — and after delivering a most interesting lecture answered many questions very capably.

The Committee welcomed Mr. W. F. S. Woodford to the February Committee Meeting and considerable time was spent in discussion on the memorandum, "Broadening the Base". As a result much enlightenment and valuable information was gained and general approval given to the principle.

It was with deep regret that the Section received news of the sudden death of Mr. C. Cursons, until recently a Member of the Committee, also the resignation from the Committee of Mr. E. M. Price, a past Chairman of the Section and a most active member.

Wolverhampton

Three lecture meetings have been held during the quarter under review. The January lecture, "Lock Design and Manufacture", by Mr. C. G. Smith, proved very interesting. In February, Dr. F. A. Wells, Ph.D., B.Sc., presented a Paper, "Economics in Production Engineering", and a most interesting talk and demonstration on "The Applications of Radio-Active Isotopes" was given in March by Mr. F. Scott, B.Sc., A.R.I.C.

Attention is being given by the Section Lecture Sub-Committee to the arrangements for the 1955 -56 programme.

Monthly meetings have been held and well attended. The Section Committee's recommendations on the Joint Education and Membership Committees' proposals on "Broadening the Base" have been summarised and forwarded to Head Office.

The A.G.M. was held in March, when the election of Officers and Committee Members took place, Mr. C. L. Old was elected Chairman and Mr. R. J. Sury, Honorary Secretary. Eight further members were elected to the Committee.

Wolverhampton Graduate

In January a Works Visit was held at Messrs. Cincinnati Ltd., Birmingham. This proved to be most interesting. A quick tour was also made around the nearby works of Messrs. Hardon, Mason and Edwards (which is owned by Cincinnati Ltd.), manufacturers of a range of power presses.

In January a Paper was read by Mr. Adams and supported by Mr. Lawrence (representing the company of Arthur Scrivener Ltd.) on "Centreless Grinding Techniques". This Paper had been compiled by the late owner of the company, Mr. Arthur Scrivener, who had unfortunately passed away suddenly only a week before. Nevertheless, the two representatives of his Company presented his Paper in a most interesting way and the Paper was supported by over 80 slides.

In February a well attended lecture on "Power Press Characteristics" was presented by Mr. Pullen, followed by lively discussion.

The February visit to Josiah Wedgwood Ltd., Stoke-on-Trent, was a great success and over 60 members, their wives and friends took part.

In March the Section convened the 5th Graduates Representatives Conference which was held at Wolverhampton. Much detailed planning had been attended to by the Chairman, Mr. E. J. V. Connelly, assisted by the Conference Honorary Secretary, Mr. E. N. Corlett, and the Graduate Committee. Also in March, the 11th Annual General Meeting was held, followed by a Paper "Ferrous Die Casting", presented by Mr. H. E. Redshaw. A works visit took place to Wickman Ltd., Coventry.

Four Committee Meetings have been held during the past quarter.

Worcester

During the first period of 1955 the Worcester Section lecture meetings were well supported. The January meeting, a lecture by Mr. J. Silver on "The Production of Jaguar Cars", was greatly appreciated.

Monthly meetings of the Committee have been held with a high attendance record and some considerable progress has been made.

NORTHERN REGION

North Eastern

The first meeting in 1955 was very well attended when a Paper on "Machine Tool Design" was presented by Mr. C. A. Sparkes, ably assisted by Mr. Hallam. A very good discussion followed when some interesting points were made in regard to the development of machine tool design to accommodate present-day materials.

The Section Committee have given a considerable amount of attention to the subject "Broadening the Base" and a comprehensive and constructive report has been submitted in consideration of the circulated report of the "Broadening the Base" Sub-Committee.

During February the Annual Dinner and Dance was held, the function being honoured by the presence of Judge John Charlesworth, together with some prominent local executives and Mr. W. F. S. Woodford. The function was very well attended and is now established on the Section's annual programme.

The February meeting aroused a good deal of enthusiasm when the members were introduced to many applications of isotopes in industry, in the Paper presented by Dr. H. Seligman, Ph.D., who is head of the Isotopes Division at the Atomic Energy Research Establishment.

It is anticipated that the March meeting will be very well attended. This has been arranged as a "Brains Trust", the panel consisting of prominent local industrial executives.

NORTH MIDLANDS REGION

Leicester

A talk at Loughborough College of Technology given by Mr. W. F. S. Woodford to students of the Loughborough Colleges and district was fully attended, and the interest developed showed that the Student Centre at Loughborough will certainly be active.

The last of this Session's lectures was given by Mr. R. M. Evans on "Materials Utilisation and the Production Engineer", owing to Mr. English being unable to give his Paper on "The Measure of Progress". The lecture gave a preview of the report that is being prepared by the Materials Utilisation Sub-Committee under the chairmanship of Mr. Evans.

Mr. L. S. Pitteway was unanimously elected as the Section's Chairman-Elect at the Annual General Meeting, and the retiring Committee Members were re-elected.

Lincoln

Since the last Quarterly Report two meetings have been held. The first was held in January at the Ruston Club, Lincoln, when Mr. Martin read a Paper written by Mr. Hodgetts entitled "Industrial Productivity Value of Work Study to Industry". The second meeting was held in February at the Technical College, Newark, when Mr. de Paula read a Paper entitled "Production Control as Applied to Small and Medium Companies", written by Mr. F. T. Hunter. This was a joint meeting with the Newark Engineering Society.

We are pleased to report that in general the attendance throughout this winter Session has greatly improved and, on one occasion, one hundred and twelve were present.

Nottingham

The lecture meeting programme for this Session closed with the Section Annual General Meeting in March, when all Section Officers were re-elected for a further term. In addition, the Section Committee has been strengthened by the addition of Mr. B. A. Green, A.M.I.Prod.E.

It is gratifying to report that applications for new members are being received in increasing quantity, particularly from students. This indicates that the younger generation are turning their thoughts more seriously to production engineering. Following efforts to encourage members possessing the necessary status to transfer to the higher grades, there has been a good response and several applications are at present under consideration.

NORTH WESTERN REGION

Liverpool Graduate

Attendance of more than 50 members and friends at the Section's lecture, "Fundamentals of Physical Metallurgy" by Mr. T. Fullwood, in February has been most encouraging to the Committee.

The visits to Messrs. J. Bibby & Sons Ltd., Liverpool, in January and to the Metrology Laboratory at the City of Liverpool College of Technology in February, were most interesting and instructive. The Metrology Laboratory had only been officially opened 10 days before the Section's visit.

The Manchester Graduate Section have been approached with a view to a closer liaison between N.W. Region Graduate Sections. Initial results have been satisfactory.

The Committee are at present arranging next Session's programme. From experience it has been found that meetings arranged early in September before night-school commences and during the Christmas and Easter night-school holidays have received the highest attendance. The Section programme will once again be based on this fact and this information may be of interest to other Graduate Section Committees.

Manchester Graduate

The Annual General Meeting of the Graduate Section was held in March. Of the retiring members of the Section Committee, two were re-elected, the remaining two having been transferred during the Session to the grade of Associate Member.

The January Annual General Meeting and Lecture on "Centreless Grinding" and the February lecture on "Powder Metallurgy" were both well received, and there was a good attendance. The average attendance showed an increase on the average during the 1953-54 Session attendance.

Contact has been made with the Secretary of the Liverpool Graduate Section with a view to closer co-operation between the two Sections. It is hoped that a joint day visit may be organised during the summer.

SOUTHERN REGION

Oxford

The second half of the Section Lecture Programme commenced with a Paper entitled "Maintenance Matters", showing the application of production engineering principles to the problems of maintenance. This was an excellent Paper, given by Mr. G. C. Oram, Works Engineer of the Appleby-Frodingham Steel Corporation, and proved of great interest to members.

At the February meeting, Mr. E. Brewer, Lecturer in charge of Management Studies at the Oxford College of Technology, Art and Commerce, took the place of Mr. B. H. Dyson and read the Paper on "Management's Responsibility for Productivity", which received a good notice in the local press. On the following day, Sir Vincent Tewson, C.B.E., gave a talk on "Productivity and the Trade Unions", arranged by the Oxford Productivity Committee, to which members of the Oxford Section were invited.

Two meetings were held during March, the first being a lecture meeting at which Mr. E. V. Beatson, Welding Development Engineer of Joseph Lucas Ltd., gave a lecture on "Some Applications of Resistance Heating to Brazing". The Annual General Meeting was held in March, followed by a film show which included "Engineers in Steel", made by the English Steel Corporation.

A most successful innovation at lecture meetings has been the serving of light refreshments during a short interval between the presentation of the Paper, and the subsequent discussion. This has proved very popular with members and guests, and has introduced a social atmosphere into the meetings.

Section expenditure has been running just within the budget, and it appears that despite increased activities, the economies made will enable the Section to complete its activities without calling for financial assistance.

SCOTTISH REGION

Glasgow

The second half of the winter programme of lectures has been successfully completed and meetings have continued to be well supported. The lectures presented during the Session have been of a high standard and the Committee hope that the programme now being arranged for next Session will be of the same standard.

Summer Works Visits will be held as in previous years and the Committee are at present considering various suggestions.

At the Annual General Meeting held prior to an open discussion on "Die Castings", Mr. M. C. Timbury was unanimously re-elected Section Chairman for the ensuing year. As a result of the ballot the five vacancies on the Committee were filled by Messrs. Ayton, Campbell, Cochrane, Staples and Young.

SOUTH EASTERN REGION

London

Lecture meetings have constituted the main activity during this quarter. In January a most interesting Paper was given by Mr. Robert Lenoir of S. Smith's, Ltd., on the development of the British clock and watch industry. In February the first lecture meeting of the South Eastern Region was held, when an excellent discussion resulted from Professor J. V. Connolly's Paper: "Does the Higher National Certificate in Production Engineering Meet the Needs of Industry ?".

Two meetings were held during March. Dr. Galloway gave a Paper on research and some of the newer techniques available today, and Mr. S. F. Smith spoke at Brighton on the measurement of surface finish.

The annual stag dinner held in February was extremely successful, although, unfortunately, neither Sir Walter Puckey nor Mr. G. Ronald Pryor could be there.

A number of members of the Committee have resigned during the year and during this quarter Mr. G. C. J. Legg and Mr. C. E. A. Griffin have resigned. This, together with the normal retirements, gave a large number of vacancies on the Committee. Furthermore, it was decided that advantage should be taken of the new regulations whereby a committee can be eighteen strong and this, too, gave more vacancies. It was necessary to hold a postal ballot at which the following candidates were successful: Merrs. H. Bennett, G. Bevan, G. R. Blakely, C. Cooper, W. Core, W. Hird, R. Hutcheson, R. Leakey, H. R. Palmer, A. C. Pike, J. Smith and R. J. C. Whitaker.

At the Annual General Meeting held in March, Mr. R. E. Leakey was unanimously elected Section Chairman for another year.

Mr. R. Hutcheson has notified the Committee that he will be compelled to relinquish the Section Secretaryship, but the Section has been fortunate in securing the services of Mr. R. J. C. Whitaker in this capacity. Mr. Whitaker has been co-opted on to the present Committee.

Arrangements are in hand for next Session's lecture programme.

Luton

During the period under review, the Section has held its first lecture meeting in Letchworth, where a growing membership is in evidence. In February, Mr. J. A. Stokes, B.Sc., lectured on "Electronics as an Aid to Productivity", before a very enthusiastic audience. For the types of industry located in Letchworth, the lecture appeared to be particularly well suited.

The lecture programme for 1955-56 is in course of preparation, and an innovation is to be tried in its form. Three formal lectures will be presented, one each in Luton, Bedford and Letchworth, with three informal lectures presented at Luton. It is hoped that this arrangement will stimulate interest in formal lectures, since this area is well served by other Institutions, and a "rationing" of such lectures may be a good thing.

SOUTH WESTERN REGION

Cornwall

In January, Mr. N. L. Laban, B.Sc., of the Bristol Aeroplane Co., presented his Paper on "The Protection of Metal Components against Atmospheric Corrosion". The audience was very appreciative and an interesting discussion developed. In February, almost 80 people turned out in poor weather to hear Mr. A. W. Marshall, F.B.H.I., speaking on "British Clock and Watch Production" Mr. Marshall dealt with innumerable questions.

It is hoped that this improvement will continue, and that the lecturers who come to this Western outpost will feel that it has been worthwhile.

There is every indication that the Compressed Air Conference in April will be a success, and some optimists are forecasting that it could be an annual event in the production engineering diary.

Western

A very successful meeting was held in Chippenham in January in conjunction with the Westinghouse Supervisors Discussion Group. At the meeting in Bristol Mr. Snell gave a most interesting Paper on all the activities which precede an aircraft engine being cleared for production. In February, despite the bad weather, a meeting was held at Swindon when an interesting Paper was given by Mr. J. E. Steel, of Sunderland, on "Mechanical Aids to Production".

A joint meeting with the Bristol and Bath Productivity Council was held, when members of the American Productivity Team gave four short addresses concerning their own individual aspects as reported in the publication: "Industrial Engineer".

The final meeting before the Annual General Meeting was held in March, the subject being the manufacture of Vauxhall motor cars.

WELSH REGION

South Wales

During the last quarter the Committee have lost the services of Mr. H. T. Jones, Section Chairman, and also Mr. E. S. Gregory, Past President, who have now left the district. Both these members had served on the Committee for many years and their resignations are a very great loss to the Section. Mr. W. H. Folds has agreed to fill the vacancy as Chairman for the remainder of this year.

Circular letters have been sent to all members on British Productivity Council activities and lecture attendances, and this should tend to increase members' interest in these important subjects.

The highlight of the lecture programme this quarter was the address given by Lord Verulam on a British Visit to Moscow. The peak figure of 140 people attended the lecture and it was of great interest to all. It is felt that this experiment was so successful that an endeavour should be made to obtain a similar type of lecture next Session.

A Ladies' Night was again organised for Committee Members and their ladies. This consisted of a theatre visit and dinner party. During the after-proceedings, presentations were made to Mr. C. L. King, retiring Chairman, and to Mr. W. D. Porter, who has relinquished the post as Hon. Secretary for health reasons.

West Wales

Much attention has been devoted to the lecture programme during this quarter and the choice of lecturers has proved to be a most happy one. The interest created in following the "More for Less" theme has been well maintained as shown by the high average attendance.

Some Committee Members have been actively concerned in Regional organisation and progress is eagerly examined at Committee Meetings.

To ensure complete consideration, a special sub-committee has been formed to investigate materials handling locally. Productivity Councils are gaining strength and influence in this area. Representative members of the Institution attend all meetings.

The Committee is pleased to record the visit of Sir Walter Puckey during this quarter and appreciates the privilege of enabling him to meet local industrialists.

Initial arrangements have been discussed for the 1955-56 Programme.

SECTIONS OUTSIDE THE UNITED KINGDOM

Adelaide

Since the last report, there has been only one General Meeting and one Committee Meeting, due to the Christmas vacation.

The meeting held in February was addressed by a member of the Section, Mr. J. L. Nunns on the subject of "Work Study and Work Measurement applied to Production Management". A circular regarding local Section activities is being sent to members each month and good interest is being maintained.

The first three membership certificates received by the Secretary were presented at this meeting, including one for the speaker. The Chairman, in presenting the certificates, made a suitable speech and the presentation proved a successful part of the meeting.

Messrs. L. G. Curtis and A. H. Uhlich, Associate Members, have joined the Committee and are working on the Membership and Education Committees respectively.

Bombay

Activities during the quarter under review commenced with a lecture meeting in January, when the Section was fortunate in having Mr. L. McP. Brooks, A.M.I.Prod.E., read a Paper entitled "Application of Motion Study on the Shop Floor". The meeting was very well attended and the lecture helped focus attention on a basic aspect of production engineering, as could be gauged by the considerable interest shown by the audience in the subject.

In February, Mr. R. A. P. Misra, a former Section Chairman, read a Paper of considerable topical interest in relation to the industrial advancement in this country when he described a scheme for the "Production of Ferro-Manganese in Electric Furnaces". In the discussions that followed, both members as well as interested industrialists among the visitors contributed to enhance the potential value of the Paper.

A number of recommendations were made by the Membership Sub-Committee at its meeting held in January. At the Committee Meeting held in February, a long agenda was discussed and a number of important decisions were made.

Canada

Mr. J. F. Milne described "Applications of Industrial Electronics" at the January meeting. In February, members were shown two films describing "The Development of the Diesel Engine".

In March, Mr. W. J. Faymonville spoke on "Food Packaging Machinery". His talk was illustrated with slides and films and was followed by a very interesting discussion.

During the quarter the Committee met each month and considered several applications for membership.

The Committee are assisting the Ryerson Institute of Technology to develop courses in production engineering which will be acceptable to the Institution.

Melbourne

The first meeting of the Melbourne Section, after the summer recess, was held in March. Ninety members and visitors attended to hear a Paper entitled "Training for Production Engineers", delivered by Mr. J. J. Chadwick, Dip.Eng., A.M.I.Mech.E., A.C.A.A., Head of the Production Engineering School of the Royal Melbourne Technical College. His Paper was preceded by a film entitled "Productivity-Key to Plenty". Mr. Chadwick then outlined the training of production engineers by his college, which is collaborated with the training system laid down by the Institution of Production Engineers. Mr. L. W. Worthington, A.M.I.Prod.E., proposed a vote of thanks to Mr. Chadwick and, in doing so, stressed the importance of adequate training.

An interesting and varied programme of lectures and works visits has been arranged for 1955.

New Zealand

No report has been submitted by the New Zealand Section, as the Section has been in recess during the period under review.

Sydney

Committee Meetings were held in December and February, and were well attended. Mr. N. Esserman and Mr. F. R. White were abroad on company business.

The Papers Committee have been busy during the recess and have prepared quite a varied programme for the coming winter. In addition to seven lectures, three works visits have been arranged, and a most successful year is envisaged.

The first Paper, "The Use of Pneumatic Aids in Production", is a most topical subject and will be presented by Mr. A. J. Elliot.

South Africa

During the month of January, the Institution was in recess and consequently no general meeting of members was held. In February a lecture on "Human Relations" was presented by Mr. R. P. Gluckman. Mr. Gluckman spoke on the all-important subject of human relationships in industry, and as he is a specialist in this vital subject, the meeting was well worth attending. A film evening was held in March.

In February a visit was arranged to the Jan Smuts Airport. The visit was very well attended and amongst those present were many members and friends from the Institute of British Foundrymen who had received a special invitation. The visit covered all aspects of the airport operations.

During the quarter the South African Council and the Membership and Papers Committee met on three occasions.

During the past months the South African Council have been considering the establishment of a Students' Section which would cater in particular for the needs of Student members of the Institution. At the time of this report no indication of interest or support for the scheme is yet known, as the various firms in the metal industries that have been advised of the scheme have not yet responded to the enquiries of the Institution.

THE BUILDING EXHIBITION

The 26th Building Exhibition will be held at Olympia, London, from 16th to 30th November, 1955. An extensive range of building materials, plant and equipment will be staged by more than 50 industries concerned with building.

The Exhibition, which is held every two years, is held under the patronage of H.M. the Queen Mother, and is still run by the organisation which started it in 1895. Full details may be obtained from the Press Officer, John Robinson, 4, Vernon Place, London, W.C.1.

Cornwall Section Conference 13th and 14th April, 1955

OVER 100 Institution members and visitors attended the first conference organised by the Cornwall Section of the Institution, at which the theme was the value of compressed air as a means of improving productivity. The Chairman of the Conference, which was held at the Cornwall Technical College, was Mr. Percy Tromans, a senior member of the Cornwall Section and Works Manager, No. 1 Works, Holman Brothers Ltd.

In his opening address Sir Walter Puckey, President of the Institution, referred to the contributions which Cornwall had made to British history—and not least, to British industrial history. Originally, he said, Cornwall's industries had been known as fish, tin and copper, but this had given way, first to tourists, tin and china clay, and now, he suggested, to tin openers, clay, flowers and mining machines ! Camborne had long been an important industrial centre : it was here that William Murdock had lighted the lamp which glowed across the whole world, and Stevenson's forerunner, Trevithick, had experimented to such great purpose. Now Camborne was the home of a flourishing compressed air industry. The compressed air engineer was lucky : his raw material was freely available everywhere, and the number of uses to which it could be put were many, and increasing. The President was sure that, in the future, compressed air would play an increasingly important part in the automatic factory.

The Theory of Compression

Mr. J. R. Quertier, in his lecture on " Compressed Air and its Compression ", pointed out that although production engineers were primarily concerned with the *application* of pneumatic tools, they must understand a certain amount of the underlying theory if they were to use that equipment to the best advantage, and maintain it properly. He therefore opened his Paper with an exposition of the theory of compression, and then discussed types of compressors and the use of ancillary equipment. Finally, he discussed recent developments : although there had been no major changes over the last few years, there had been a gradual swing to air-cooled machines, and a trend towards higher pressures. There was also an increasing use of oil-free compressors. Mr. Quertier also described the air-cooled rotary now being made for portable work, and the free piston compressor developed in Germany during the War and now appearing in single stage and two-stage forms as a portable compressor for general contracting work.

Two Papers were given during the second session. Mr. F. B. Coombes, Chief Designer, Holman Bros. Ltd., spoke on " Pneumatic Tools, Their Air Supply and Maintenance ", and Mr. W. G. Bennett, Manager of Climax Rock Drill and Engineering Co. Ltd., dealt with " Air Operated Equipment ". Mr. Coombes

Mr. Percy Tromans, Chairman of the Cornwall Section Conference, welcomes the President of the Institution, Sir Walter Puckey.

Southern Section Dinner Dance

The Southern Section Dinner Dance, held in Southampton on 23rd March last, was, as usual, a highly enjoyable function. Included in this group are the Mayor and Mayoress of Southampton; Principal F. T. West, Section Chairman, and Mrs. West; Sir Hugh Walmsley and Lady Walmsley; Mr. N. J. Cottell, Past President of the Southern Section, and Mrs. Cottell; Mr. S. P. Woodley and Mrs. Woodley; Mr. J. W. Taylor, Section Hon. Secretary, and Mrs. Taylor; Mr. W. F. S. Woodford, Institution Secretary, and Mrs. Woodford; and Mr. S. Caselton, Assistant Secretary to the Institution, and Mrs. Caselton.

dealt separately with a large number of tools, considering first the function and maintenance of rotary type machines and secondly of percussive machines, with, in each case, a statement of the general principles applicable to all tools of the group. He emphasised the importance of all tools being returned to stores at the end of the shift, for examination, cleaning, lubrication and testing; the two latter were of special importance. Mr. Coombes described some simple methods of testing, and also methods of ensuring adequate maintenance where daily return to stores was impracticable. In his Paper, and throughout the Conference generally, special attention was paid to the problem of water in the air and its effect on tools and their maintenance. Mr. Bennett's paper consisted of descriptions of the air control mechanisms of a large number of typical applications, and delegates found most enlightening his descriptions of their intricate operation.

The final lecture, "A User's Experience", was given by Mr. W. E. Wright, Chief Planning Engineer, Engine Production Factory, Bristol Aeroplane Co. Ltd. He described how each factory of the company employed a closed ring circuit into which all the main compressors fed. There were 21 compressor installations in all. Mr. Wright described 27 differing types of compressed air utilisation which were employed in the Bristol Aeroplane Company's factories, and then discussed the uses of compressed air in the research departments. Members of the Conference were impressed by his statement that the three "slave" compressors used there delivered 108,000 cu.ft. a minute at maximum output—a total weight of 3½ tons a minute, which was equal to the amount breathed by about seven million people at the same time.

The guest speaker at the Conference Luncheon on 13th April was Mr. A. W. Grant, C.B.E., Chairman of the Engineering & Allied Employers' West of England Association, who spoke of the importance of increased productivity at the present time, and gave a fascinating account of the important work being done in Bristol on work study courses, not only for senior staff, but for shop stewards.

At the final session of the Conference, the chair was taken by Mr. C. D. Alder, Principal of the Cornwall Technical College, who introduced Mr. A. T. Holman, Chairman of Holman Bros. Ltd. Mr. Holman, summing up, concluded that the Conference had shown that compressed air was, and would continue to be, a most valuable contribution to productivity. Its major advantages were flexibility, simplicity, adaptability, speed of operation, reliability at abnormal temperatures, compressibility, retention of stored power, safety, universality and conveyability. In conclusion, Mr. Holman congratulated the Cornwall Section and in particular their Hon. Secretary, Mr. F. G. Hawke, on this most successful conference. Finally, Mr. Percy Tromans, Chairman of the Conference, thanked the Cornwall Technical College for its generous hospitality, the speakers, and all who had taken part in the Conference.

On the Thursday afternoon, members of the Conference went to see the last Cornish engine at work, in Robinson's shaft on the South Crofty Tin Mine. This pump, over 100 years old, was to end 50 years' continuous working the following week, when electric pumps would take its place. Later in the afternoon, members visited the Holman Museum, where they saw an impressive collection of old and new pneumatic tools and equipment.

Mr. R. W. Tuck, Member, General Manager, No. 1 Factory Group of C.V.A. Jigs, Moulds & Tools Ltd. for the past 11 years, has been appointed Project Engineer to develop new plants.

Mr. J. Barr, Associate Member, has relinquished his position as Feeding Departments Production Manager with Mechans Limited, Scotstoun, Glasgow, to take up an appointment as Works Manager with F. W. McConnel Limited, Ludlow, Shropshire.

Mr. W. Bone, Associate Member, has taken up an appointment as Training Officer (Engineer III) in the United Kingdom Atomic Energy Authority, Springfield Works, Preston.

Mr. D. J. H. Bridge, Associate Member, who was previously Technical Representative of Fisher & Ludlow Limited, Birmingham, has now been appointed Sales Manager (Midlands).

Mr. C. V. V. Chetti, Associate Member, who was Principal at Tamilnad Polytechnic, is now General Superintendent at the Government Industrial Engineering Workshops, Washermanpet, Madras 21, India.

Mr. C. Copper, Associate Member, has relinquished his position with Joseph Lucas Limited, and is now a Director of Clear Hooters Limited, Birmingham.

Mr. R. J. Dixon, Associate Member, has been appointed a Director of Wickman Limited, Coventry. Mr. Dixon who is the Chief Engineer of the Company, was appointed a Special Director in 1953. He joined the firm in 1929.

Mr. J. H. Forrington, Associate Member, Works Manager of Townson & Mercer Limited, Croydon, has now been appointed a Director.

Mr. J. Lavin, Associate Member, has relinquished his appointment as Production Engineer to Cooke and Ferguson Limited, and is now Chief Production Engineer to British Oxygen Engineering Co. Ltd., Edmonton.

Mr. E. B. Loewendahl, Associate Member, has been appointed Assistant General Manager, in charge of works, planning and organisation of the Central Tool & Equipment Co. Ltd., Hemel Hempstead, where he was previously Planning and Production Engineer.

Mr. J. L. Stevenson, Associate Member, has relinquished his appointment as Assistant Lecturer of the Technical Institute, Yaba, Nigeria and is also retiring from the Colonial Civil Service. Mr. Stevenson has been in Nigeria for 27 years.

Mr. B. E. Stokes, Associate Member, recently relinquished his position as Manager of Production Planning and Control with Joseph Lucas, Ltd., Birmingham, and is now Production Engineer with British Tabulating Machines, Ltd.

Mr. Stokes, who was one of the two winners of the 1950 Schofield Travel Scholarships, serves on the Education and Editorial Committees of the Institution, and is a Member of Council.

Mr. G. E. O. Taylor, Associate Member, has now been appointed Admiralty Regional Radio Inspector in charge of the A.S.R.E. Southern Region Inspectorate, London.

Mr. G. Thompson, Associate Member, has recently taken up an appointment as Machine Shop Superintendent with Henry Simon (Eng. Works) Limited, Cheadle Heath, Stockport.

Mr. R. H. S. Turner, Member, Works Manager of Metropolitan-Vickers Electrical Company, Ltd., has been appointed to the Board. He joined the firm in 1930, as a college apprentice, and following appointments in the Erection, Instrument and Meter, and plant Departments, became Superintendent of the Plant Department in 1948. He was appointed Assistant Works Manager of the Main Works at Trafford Park in 1952, and Works Manager in 1954.

Mr. Turner, who is a Past President of the Manchester Section, and a past Member of Council, is also a corresponding member of the Institution's Papers Committee.

Mr. P. E. Verrall, Associate Member, Sales Manager of Smart & Brown (Machine Tools) Limited, has been elected to the Board of Directors.

Mr. D. H. Broome, Associate, has relinquished his position with I.C.I. Ltd., (Metals Division), as Assistant Distribution Manager (Tubes), and has now taken up an appointment as Commercial Manager, T.I. Plastics Limited, Stoke-on-Trent.

Mr. N. R. Smith, Associate, has been made a Director of L. M. Van Moppes & Sons (Diamond Tools) Ltd., Basingstoke.

Mr. A. G. Coltman, Graduate, has relinquished his position as Assistant Departmental Engineer with British Celanese Limited and is now a Production Engineer with Brockworth Engineering Co. Ltd., Hucclecote, Gloucester.

Mr. R. Howard, Graduate, has recently taken up a position as Designer at the Laboratories of the Plessey Company at Towcester.

Mr. G. Shaw, Graduate, has left Wireless Telephone Co. Ltd., and has now taken up an appointment as Technical Representative for Lang Pneumatic Limited in the Northern area. Mr. Shaw is Hon. Secretary of the Sheffield Graduate Section.

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REVIEWS & ADDITIONS

"Comprehensive Guide to Factory Law": *a classified guide to the requirements of the Factories Acts and other legislation affecting factory occupiers,* by Robert McKown. *Chantry Publications, London,* 1954. 122 *pages.* £1 1s. 0d.

One of the outstanding differences in production and works management between the period before the Second World War and that after, is the growing influence of the law on the everyday work of production engineers and managers. Nowadays, the production engineer is surrounded by a sea of legal obligations and duties, many of which were entirely unknown to his predecessor 20 years ago.

These duties and obligations, a large number of which are not part of Statute Law (i.e. written law) but are Common Law (i.e. unwritten law) duties, are often confusing to the mind of even the well-informed manager.

Excellent books have been published from time to time on various aspects of Factory Law; Redgreaves on the Factories and Shop Acts, and Munkman on Common Law Aspects, are but two examples of specialist works, useful for lawyer and layman. A really comprehensive guide, however, to all practical aspects of Factory Law was still required, and Mr. McKown's book was therefore eagerly looked forward to by many engineers and managers. It was hoped that it might provide not only a means of informing the practising manager of the full extent of his legal duties, but also give the meaning of some of the terms used in regulations and orders, as interpreted by the Common Law Courts.

Does Mr. McKown's book fulfill these expectations? The answer to this question is twofold: in classifying the provisions of the Factories Acts, and similar Statutory legislation, and in presenting these in a manner more easily understandable than the original Acts and Orders, it does. However, in presenting a balanced picture of a manager's present-day legal obligations in the Factory, it must be adjudged a failure.

McKown's "Comprehensive Guide to Factory Law" is a well classified statement of Statute Law. Its 16 Sections deal not only with definitions of premises affected by the Factories Acts, factory buildings, machinery, electrical equipment, but also with the Statutory requirements in connection with building operations, the loading and unloading of ships and special industries.

This competent classification of Statutory obligations is only partly marred by the Author's omission of some of the excellent interpretations given by the Courts, explaining terms difficult to understand, e.g., the reader is left to think out his own interpretations of the meaning of such terms as "safe means of access".

Whilst the Statutory part of Factory Law is comprehensively dealt with by the Author, his treatment of the Common Law obligations is no more than perfunctory. To managers of factories, the increase in importance of this side of the law has been a striking development during the post-war years, and damages awarded by Courts for breach of Common Law duties have increased steadily. It is therefore unfortunate that the Author should have allowed four pages only to cover this important section.

To sum up: McKown's "Comprehensive Guide to Factory Law" is an excellent guide to Statutory legislation, well classified, and with many tables to help managers in various industries.

In spite of the fact that it is not what its name implies, *viz.* a *comprehensive* guide to Factory Law, it will undoubtedly be found of value, not only to the executive requiring it for reference purposes, but also to the student and graduate preparing for industrial administration examinations. **H.P.J.**

"Cost Accounting and The Engineer" by Kenneth B. Mitchell, *Iliffe for Machine Shop Magazine, London,* 1954. 126 *pages.*

The first chapter of this book sets forth the reasons for cost accounting and makes the case for it. The following chapters set out to outline the techniques in an understandable form to the engineer.

The chapter on introduction to costing is well set out, detailing the objects of costing, the formal estimates used, and asks some very pertinent questions of Company Executives, e.g., "Is the incentive scheme working to the fullest advantage?" and shows that the answers to such questions are contained in the Cost Department records.

It points out that it is the duty of responsible engineers to take advantage of this service which is available to them, provided the information is presented in a manner they can understand.

From the case for cost accounting and a really concisely put introduction to it, the Author proceeds to cover lucidly the costing of material and labour.

The control of overheads and their application are dealt with in the next chapters and by the end of Chapter VII final costing has been dealt with. This is unfortunately a stage where a great many engineers consider that their knowledge of costing should cease.

The first half of the book is completed by a chapter on the influence of Fixed and Variable costing.

Part II is devoted to budgeting and budgetary control, outlining the purposes of budgets and the very strong reasons for them, emphasizing the fact that only too frequently it is hard economic reasons that force them on some managements through sheer necessity.

The use of illustrations of standard forms and charts, etc., is kept to a minimum so that the mind of the reader is able to closely follow the Author's reasoning.

The book should prove of great use to teachers in Technical Colleges, taking management subjects, and should also prove extremely useful to engineering executives rather than accountants. **D.H.M.**

"The Social Psychology of Industry": *Human Relations in a Factory,* by J. A. C. Brown. *Penguin Books, Harmondsworth, Middx.,* 1954. 310 *pages.* 2s. 6d. (A Pelican Book.)

This book gives one psychologist's point of view as to the causes of industrial unrest. It brings together most of the latest ideas and knowledge on motivation, leadership, informal grouping, frustration and human nature generally.

Let no industrialist, however, be deterred by the fact that it has been written by a psychologist. It is an intensely readable book. If industry is ever to be rescued from the Slough of Despond in which it always seems to have wallowed, then responsible people must give some attention to the thoughts expressed in this book. Every manager should have a copy under his pillow to read and re-read before he falls asleep.

The Author wishes to rub in the fact that managers no longer have a stick to wield and even donkeys will not thrive on a diet which consists solely of carrots. Here are a few extracts from a book which all clear-minded industrialists will find delightful reading:

". . . . the position of management in relation to workers . . . . is . . . . that of the parent who takes his problem child to the Child Guidance Clinic, and is disturbed to find that the psychologist works on the principle that 'there are no problem children, only problem parents'. Most of the work in modern child guidance is taken up with the treatment of the child's parents who are the cause of its misbehaving,

and if the parents refuse to co-operate in admitting where they have been mistaken, nothing can be done for the child ".

" . . . . the belief that money is the sole, or even the most important of several, motives for work, is so foolish that anyone who seriously holds this opinion is thereby rendered incapable of understanding either industry or the industrial worker ".

" . . . . Lord Montgomery, as Commander of the Eighth Army, made it a rule that the plan of campaign should be made known to every soldier in the Army, and it was fully discussed by groups of men at all levels, but the average factory manager would consider such a proposition as completely absurd, Utopian and dangerously revolutionary ".

" . . . . if the incidents so frequently reported in the daily papers have made it appear that industrial workers behave in childish and incomprehensible ways, it should be remembered that, firstly, these incidents have been torn out of their contexts . . . . and secondly, that there is no behaviour on the part of workers which is not exactly paralleled by management ".

The Author concludes that " A genuine industrial democracy can only be based on the intelligent co-operation of primary working groups with responsibly minded managements " provided that the politicians have brought about " a state of affairs in which it is possible for the industrial worker to feel that his own interests and those of management coincide " and also that the vested interests of the Trades Unions have been taken care of.

How all this is to be done is not the concern of psychologists as such. D.E.G.

" Production Tooling Equipment " : ***The Design of Jigs, Tools and Gauges,*** by S. A. J. Parsons, B.Sc., M.I.Mech.E., M.I.Prod.E., A.M.I.I.A. *Cleaver-Hume Press Ltd., London,* 1954. 324 *pages. Diagrams.* £1 5s. 0d.

When describing the contents of a book on tooling it is difficult to make the work sound anything but very ordinary. Therefore I must start by saying that this book is very far from just ordinary.

There are 300 pages of well planned and well written information. The Author has very wisely confined himself to a definite section of tooling. He covers jigs, fixtures, clamping and cutting tools. He spends some time on various cutting processes and tool layouts. Novel features are the concluding chapters on quality control, gauging and tooling economics. The appendices are very sound guides to would-be students, by describing how and what to study for various examinations.

It is a pity some other aspects of tooling are not covered, *viz* :- press work, mould work, etc., but perhaps one day we might have this pleasure in a revised edition.

There does not appear to be a word wasted in this book, consequently it would be very difficult to give a precis. It must remain sufficient to say that every word is worth reading.

It is obvious that Mr. Parsons has a vast fund of production engineering experience which he is very able to impart to readers of his book.

It says on the front cover that " Production Tooling Equipment " is officially approved for our Institution's Associate Membership Examination. I would add more than that and say that it should be very highly recommended. R.E.M.

" A Career for the Graduate in Industry " *Federation of British Industries, the Federation, London,* 1954. 24 *pages.* 2s. (F.B.I. Handbook.)

" Industry and the Graduate " *Federation of British Industries, the Federation, London,* 1954. 31 *pages.* 2s. (F.B.I. Handbook.)

These handbooks, the first addressed to the undergraduate, the second to those who frame staff recruitment policies, have a common purpose, namely to raise, or at least to maintain, the standard of management in British industry.

Statistics, so simply and yet so cunningly stated as to be almost misleading, are used to support the argument that the country's educational policy is depriving industry of the cream of intelligence at normal school-leaving age. It is contended that the best brains are being fed to the Universities, and that industry must not fail to reclaim its full share after graduation.

It is not in the technical and scientific sphere alone that this policy is recommended—in fact, one of the principal aims of the handbooks is to encourage the employment of Arts graduates in managerial posts.

To the undergraduate, after a brief description of British industry, is given an assessment of the place of the graduate in industry and in the individual firm. His prospects are stated in a sensible and practical manner, and he is warned not to aim too high, but to realise that " those who manage, normally emerge from the ranks of those who do things ".

No indication is given of the range or method of distribution of the former handbook. It is to be hoped that a copy will be within reach of every undergraduate who is not definitely committed to a career outside industry, and that he will be encouraged to study it. The " ability to think " which a university education creates, and the breadth of vision which results, could in the future transform our standard of management. If this booklet encourages young men to look upon industry as a first choice for a career, rather than as a last and unwelcome resort, it will have achieved its purpose.

But industry itself must realise the need for the recruitment of more graduates, and it is to this end that the latter handbook has been written. Particular stress is laid upon the potential value of the Arts man in management. A point which is not always appreciated could have been made more forcibly, namely that a Pass degree, which succeeds a less specialised course of study than an Honours degree, may in fact provide the better man for non-technical posts. Much of the advice given to the undergraduate, and the assessment of his future and his opportunities, is here repeated from the employer's angle.

Other industries are visited to follow the lead of engineering in arranging Vacation Courses for undergraduates, which not only provide an insight into the mysteries of factory and office life, but give confidence when entering permanent employment. The first few years of the graduate's industrial life are vital, and much care and thought should be given towards framing a progressive path of experience.

Employers who are considering the recruitment of graduates are advised to establish contact with a university through the Appointments Board, and to indicate clearly their requirements. An Appendix gives the name and address of the Secretary of the Appointments Board of each University and University College.

This handbook is being distributed to all F.B.I. member firms. It will be read with interest and advantage by the many enlightened employers who can appreciate its message. It is sad to reflect that probably very few of those who most need to learn its lesson will take the trouble to read it. J.E.

" Practice Notes " Society of Incorporated Accountants, London, *the Society, London,* 195- in progress.

These " Practice Notes ", which have been issued by the Incorporated Accountants Research Committee, take the form of a series of papers by various authors. To date 35 of these papers have been received.

The papers cover a wide range of subjects of varying interest to production engineers. On the one hand, there are some papers with special reference to industry such as :-

(a) Budgetary and Financial Control, by W. F. Edwards, F.S.A.A. Director and Treasurer of General Motors Ltd.
(b) Management by Budget by P. N. Wallis, A.S.A.A.
(c) The Elements of Management Accounting, by C. E. Sutton, A.S.A.A., F.C.W.A.

On the other hand, most of the papers are likely to have little direct appeal to many production engineers. These papers deal with such specialist matters as " Taxation of Foreign Income ".

The papers on budgetary control and allied matters are of a high standard and can be appreciated to a large extent by people without specialist training in accountancy.

H.H.N.

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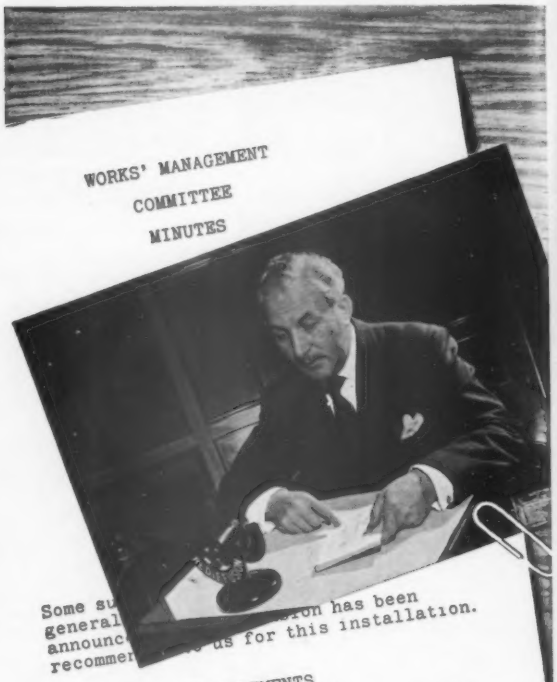
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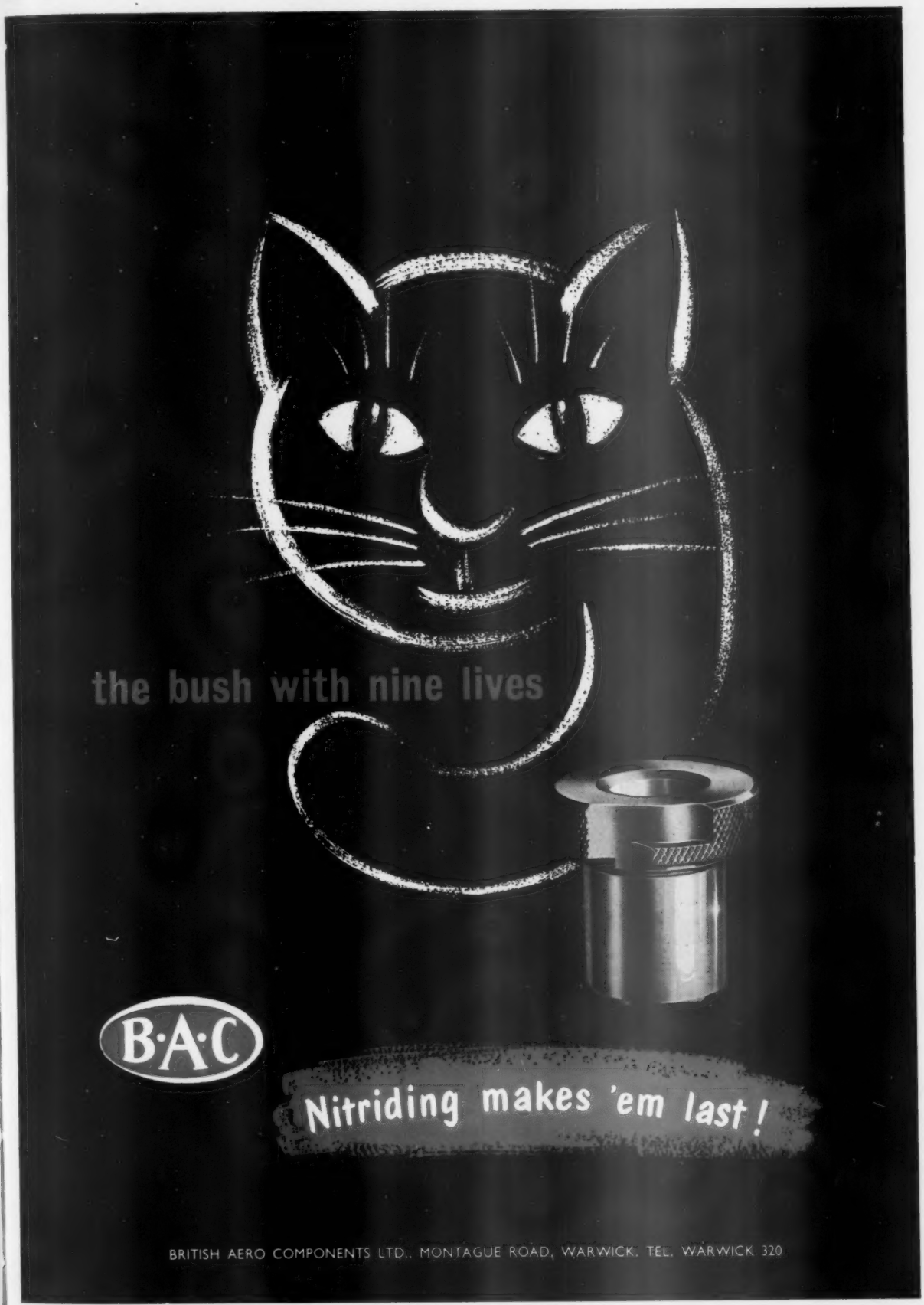
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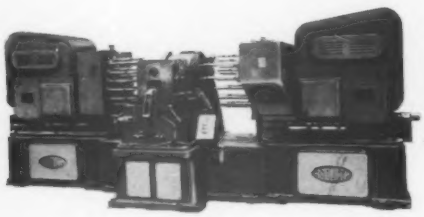

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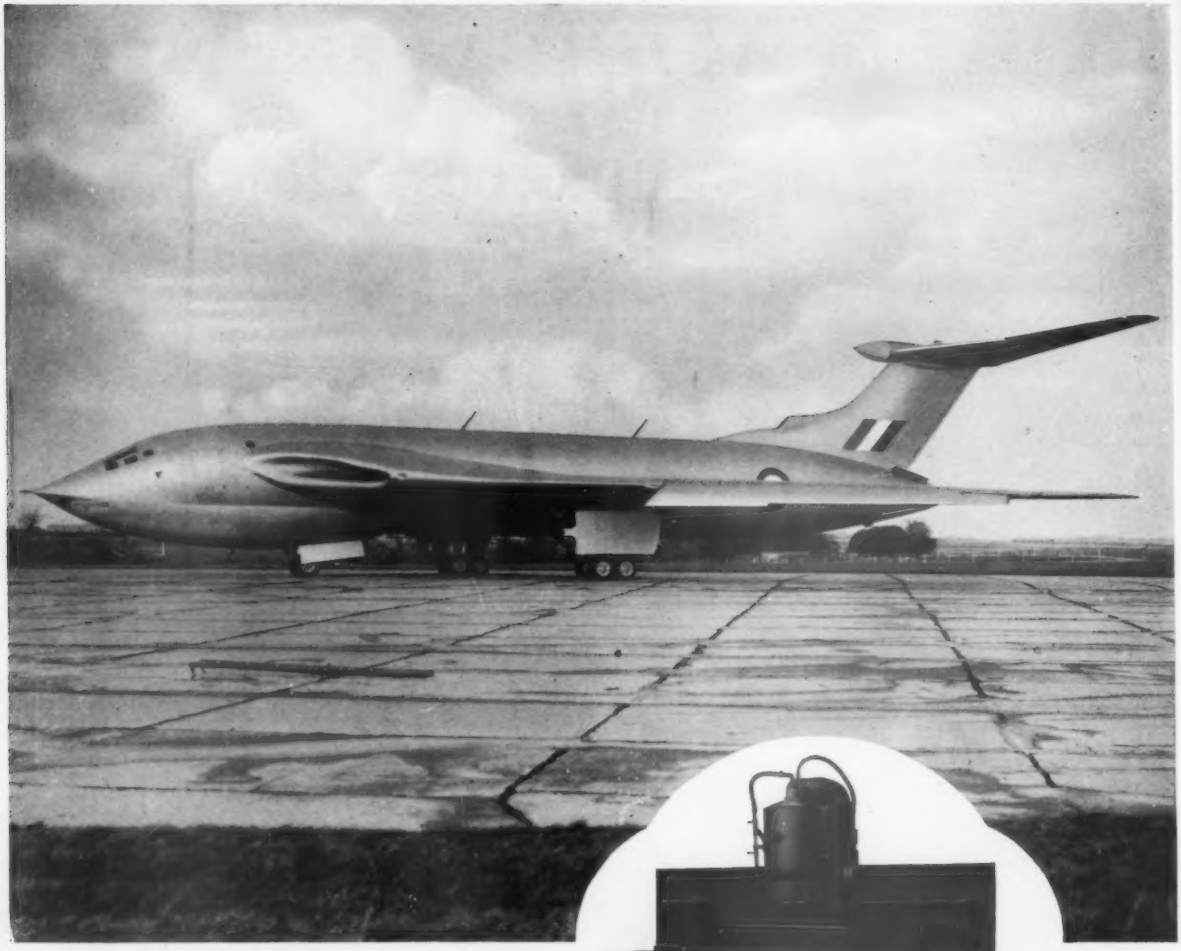

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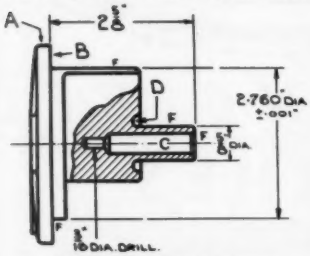

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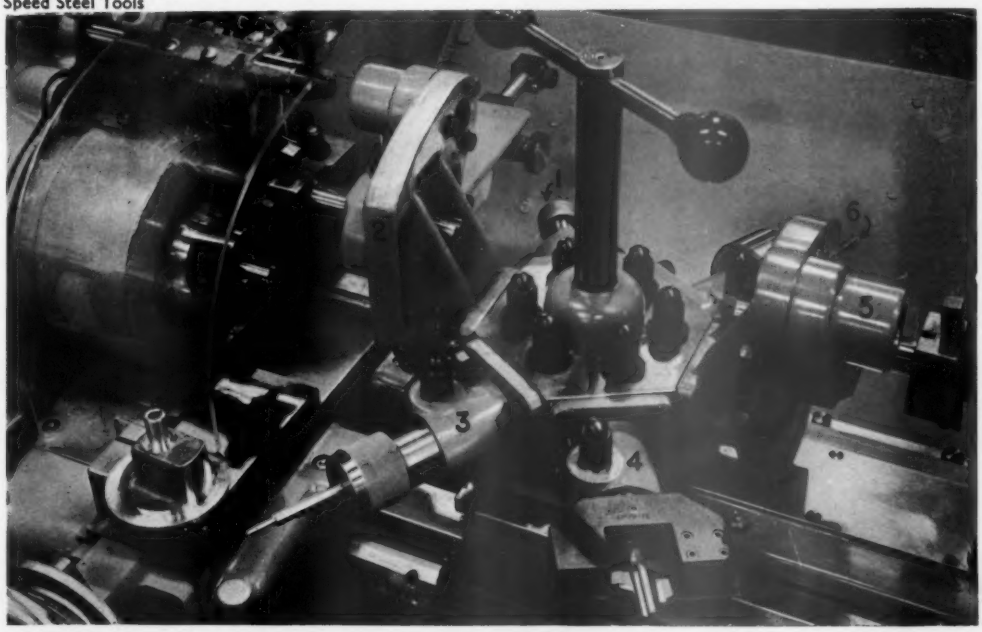
DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
Chuck externally at A	—	—	—	—	—
Face Flange B	—	Rear	2041	2000	Hand
Start Drill C	1	—	2041	200	Hand
Drill and Knee Turn 2·760" dia.	2	—	2041	1475	120
Drill ⅜" dia.	3	—	2041	100	Hand
Bore C, Turn ⅝" dia. and recess D and Face End	4	—	2041	535	120
Finish Knee Turn 2·760" dia.	5	—	2041	1475	120
Ream C	6	—	321	30	Hand
Remove	—	—	—	—	—



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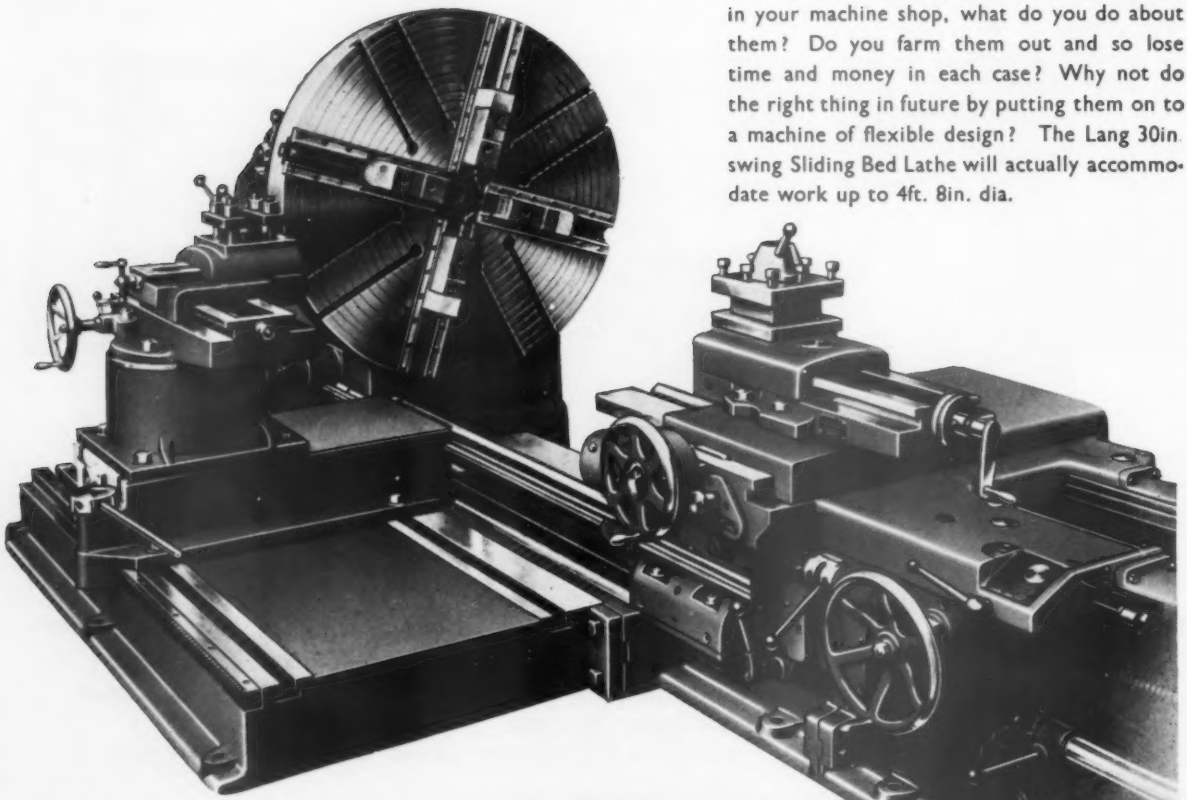

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See the Conference Issue (June 10, 1955) of

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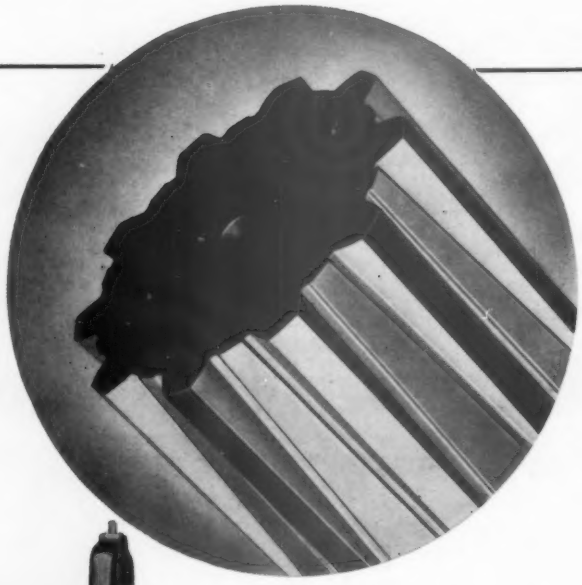

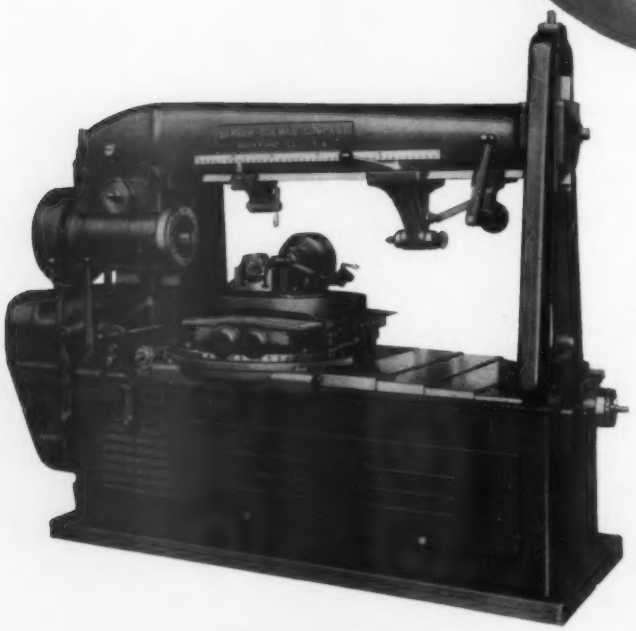

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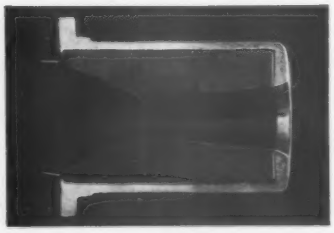

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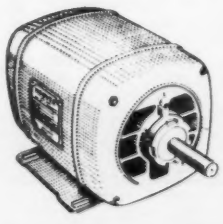

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Having a hand in Productivity

In every industry or trade, electrical equipment is the key to modern production methods. There are probably more production-boosting and money-saving devices than you know of. Your Electricity Board can help you and give you sound advice.

They can also make available to you, on free loan, several films on the uses of electricity in Industry — produced by the Electrical Development Association.

E.D.A. are publishing a series of books on " Electricity and Productivity ". Four titles are available at the moment; they deal with Higher Production, Lighting, Materials Handling, and Resistance Heating. The books are 8/6 each (9/- post free) and the Electricity Boards (or E.D.A. themselves) can supply you.

One man fires 12,000 dozen pieces a week

He does it electrically — in a multi-tunnel kiln. There are 16 tunnels and the ware in adjacent tunnels travels in opposite directions so that the incoming ware picks up heat from the outgoing. The ware is pushed through each tunnel in a series of predetermined steps, controlled electrically. All the operator has to do is to feed the ware into the kiln and take out the finished pieces—144,000 of them a week. Biscuit firing, glost firing or decorating, tea ware, dinner ware, tiles or 'fancies' — the electric kiln does it all. Higher output at low heating cost per article is

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a Power of Good for PRODUCTIVITY

The British Electrical Development Association
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Precision Automatic Model 1.h.

FOR RAPID PRODUCTION AND CLOSE ACCURACY

Largest dia. of component (Brass) ..	.275″
Largest dia. of component (Steel) ..	.236″
Maximum length of component ..	2.952″
Spindle speeds	1980—6000 R.P.M.

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MODERN DESIGN · EASY SETTING PRECISION WITH EFFICIENCY...

Maximum gear dia.	2.480″
Maximum face width	1.575″
Maximum pitch module	.8
8 cutter spindle speeds from 500—2500 R.P.M.	

Precision Automatic Model G.12.

VERSATILE IN USE · SIMPLE IN SETTING · ELECTRICAL CONTROL

Largest dia. of component, round	12.7 m/m.
Maximum length of component	140 m/m.
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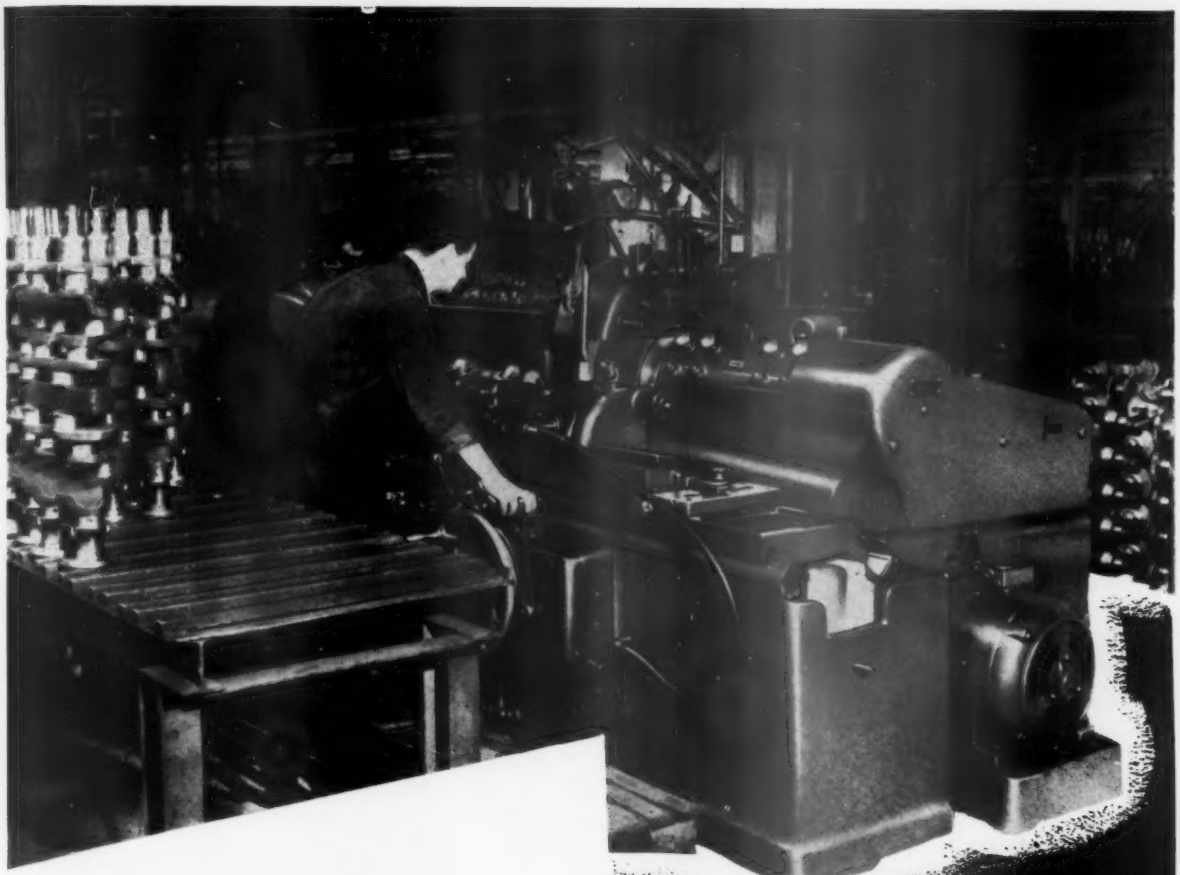

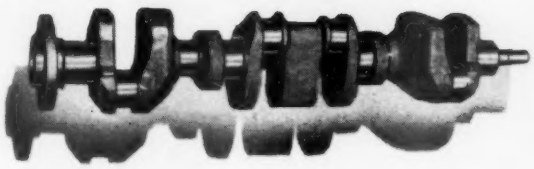

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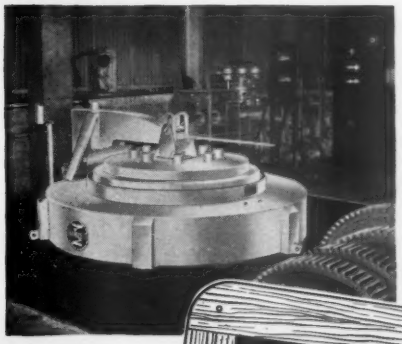

top: two 100 kW units, 27" diam. x 54", for heavy gear parts.

centre left: gas fired unit, 48" diameter x 48" deep, using endothermic atmosphere generator.

centre right: the smallest standard pit unit; 40 kW furnace with drip-feed carburising system.

bottom: two 65 kW furnaces, 24" diameter x 42" deep, with (rear) pit tempering furnace and (front) the gas atmosphere generator.

Birlec Publication No. 70 gives full details; it will gladly be sent.

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- ✓ Birlec Limited has over 70 standard pit gas carburising furnaces in commission, providing comprehensive experience on atmosphere control, loading and charge handling techniques and time/temperature cycles.
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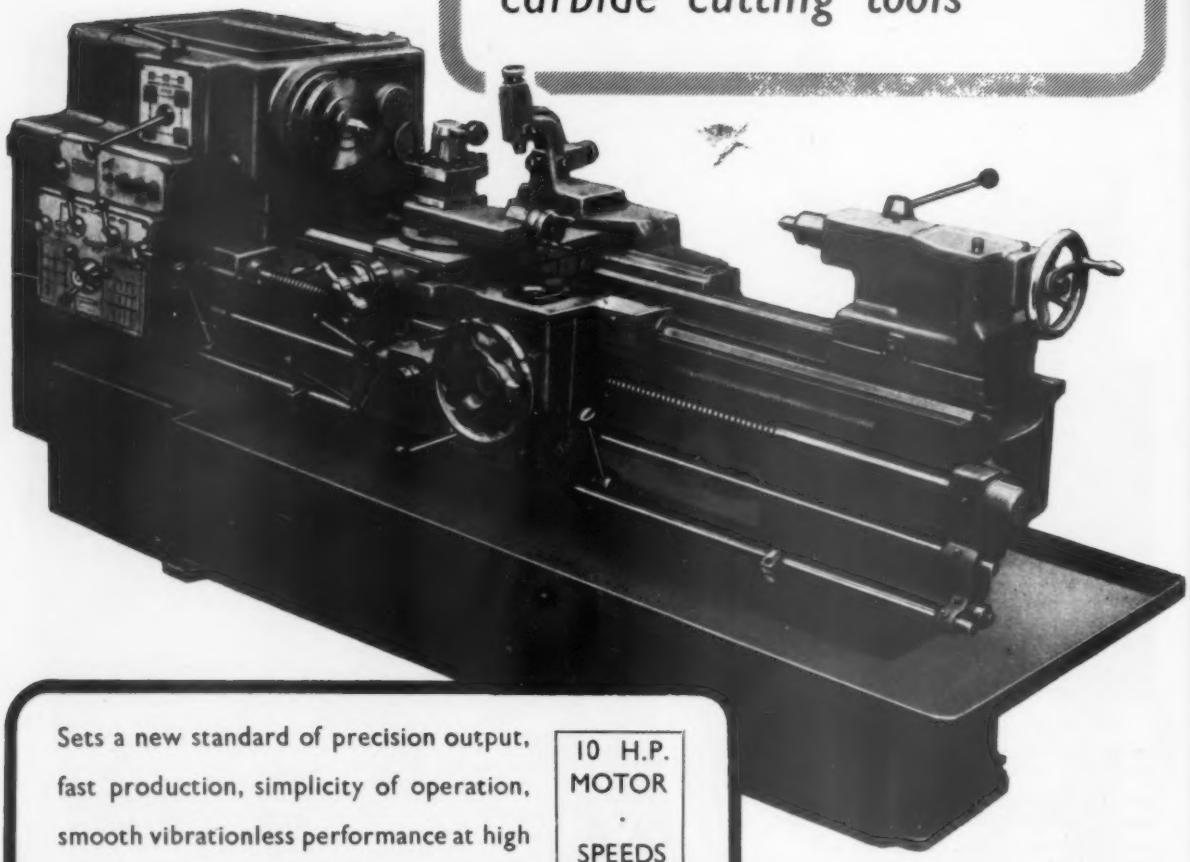
The WM '85'

8½" CENTRE LATHE

A heavy duty lathe suitable for use with the modern carbide cutting tools



Sets a new standard of precision output, fast production, simplicity of operation, smooth vibrationless performance at high speeds, robust construction and accessible disposition of controls.

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SPEEDS 21—945 r.p.m.

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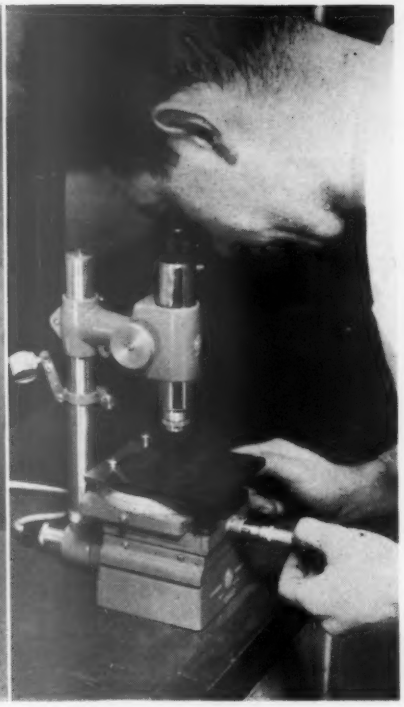

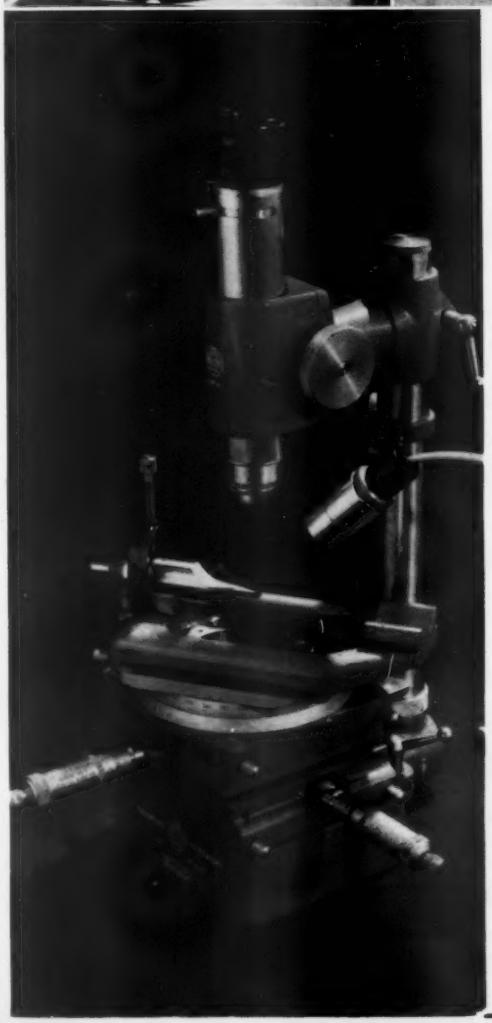

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The above Rolls, produced by C. E. Johansson Ltd. from specially selected and heat treated steel to a very high degree of accuracy, ensure perfect thread forms and long tool life.
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The smallest panel-mounting contactor on the market

50% saving in weight and size.

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Coils and contacts changed in a matter of seconds.

Exceptionally low wattage consumption. C.S.A. approved.

Conforms with American N.E.M.A. specification.

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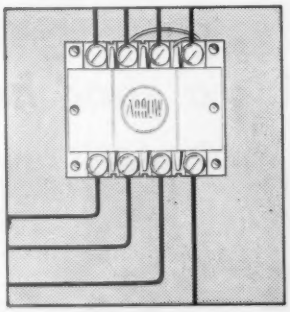
This is a completely new, built-in, advanced wiring design. Installation time is greatly reduced and circuit identification is easy and positive.



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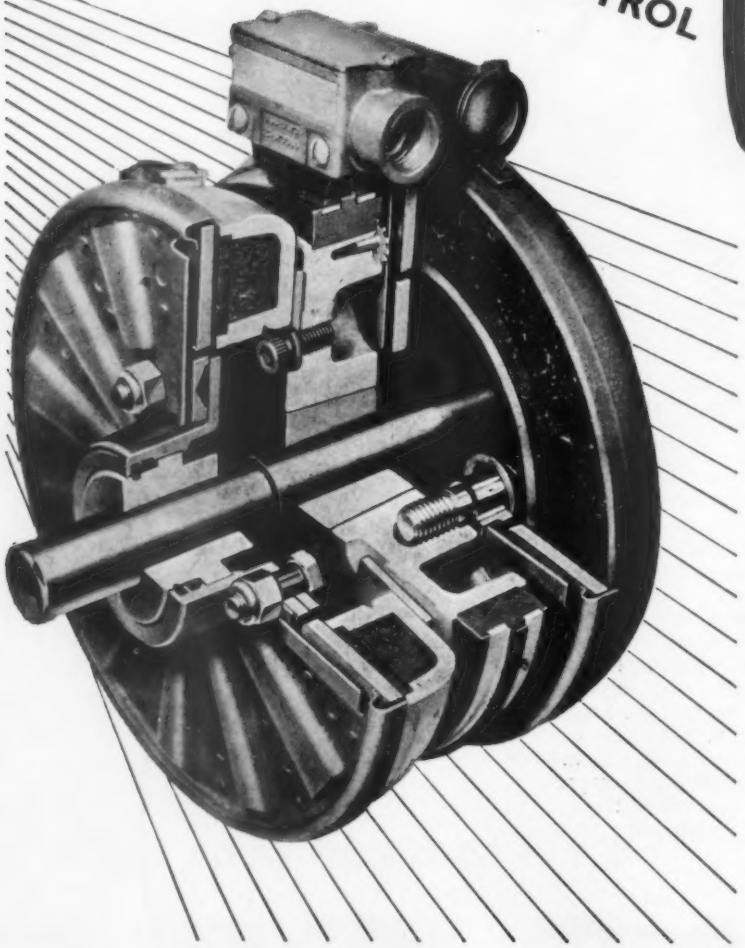
Quick action

with smooth cushioned stops and starts

GIVES UNPRECEDENTED CONTROL



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are world renowned for accurate, shockless and instantaneous control of rotating drives.

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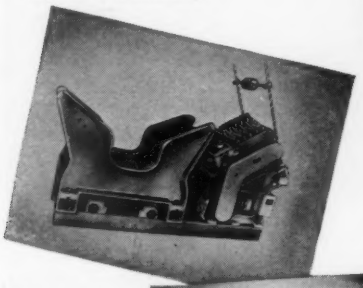
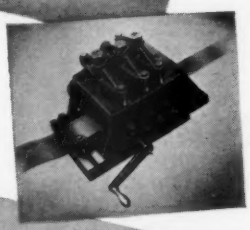
Increase your press output by efficient handling of coil stock

This equipment converts an ordinary press to fully automatic operation. Saves time, labour and material. All machines built in England to original design of The U.S. Tool Co. Inc., pioneers in this particular field in the U.S.A.

Combination Automatic Coil Cradle and Stock Straightener
For material ¼" thick by 12" wide, larger models available.



Plain Stock Straightener
For use with Slide Feeds – range from 2½" to 12" wide.

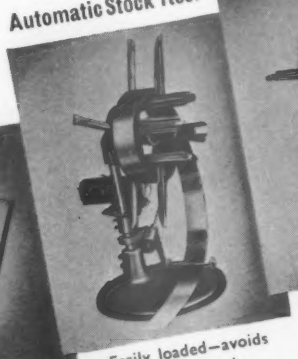


Power Driven Straightener
For coiled stock or short lengths. Available from 6" to 48" wide.

Horizontal Reel

For feeding flat stock vertically

Automatic Stock Reel

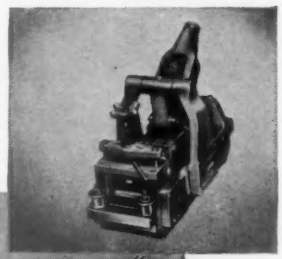


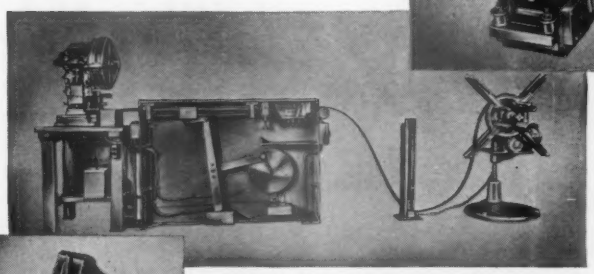
Easily loaded—avoids strain and snatch.

Plain Stock Reel

Plain Reels available in six sizes.

Precision Slide Feed
Makes press fully automatic. Available up to 20" wide.





Slide Feed for Very Long Pitches
Fully motorised independent Feeds.

Cycling Feed
Feeds any preset length of material automatically.

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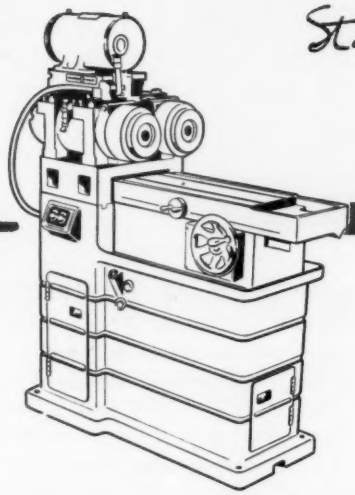
EC28

THIS FINE BORING MACHINE SHOWS A BIG SAVING IN THE *Finish*

DECLARES

Stanley Howard.



All fine boring machines give a high finish to close limits at low cost—at the start.

But Boneham & Turner boring machines continue to meet these requirements year after year, and that's why they're so much cheaper—in the finish.

So whether it's the single-ended type S.E.14 shown above or the double-ended type D.E.14, ring Stanley Howard today for further details—without obligation, of course.

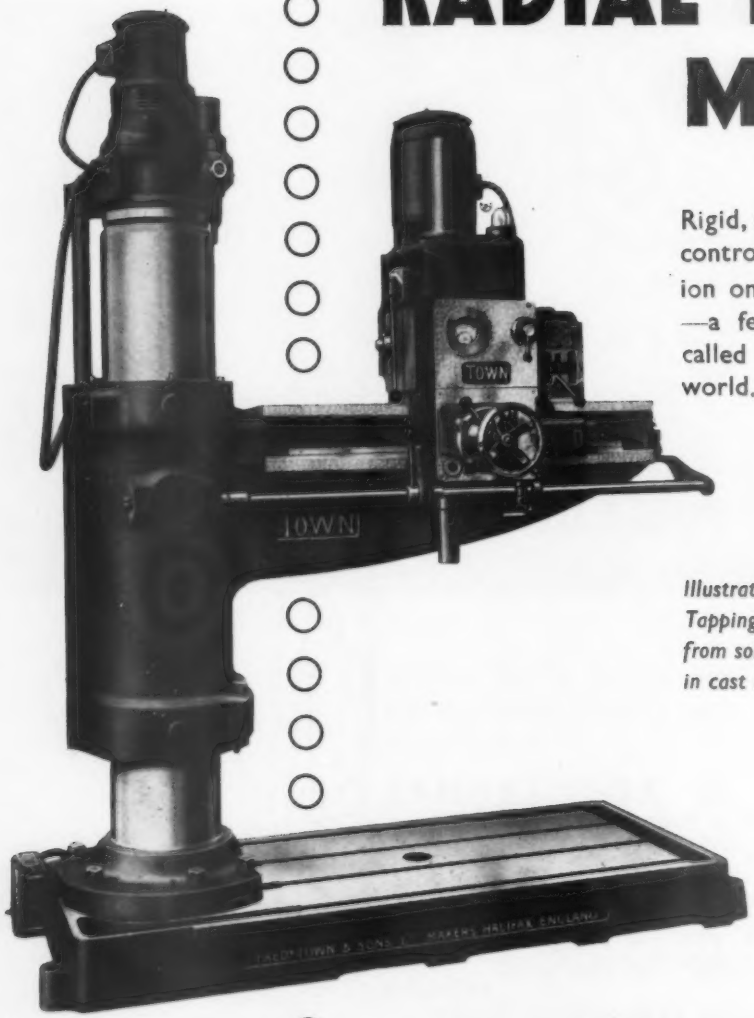
B&T

FINE BORING MACHINES

AGENTS

TOWN

RADIAL DRILLING MACHINES



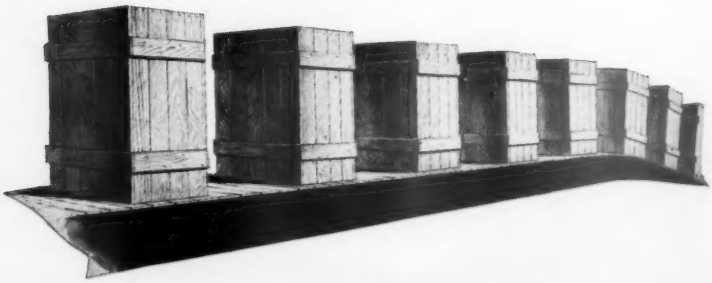
Rigid, simple design, conveniently placed controls and maximum rates of production on the widest range of components —a few of the reasons why they are called upon to give service all over the world.

Illustrated: Town 5ft. A.E.4 Radial Drilling, Boring, Tapping and Studding Machine Drilling capacity from solid 2½in. diameter in steel and 3in. diameter in cast iron. Tapping 1¼in. Whitworth.

FREDERICK TOWN & SONS LTD

HALIFAX · YORKS

we were all over the place



until we called in KING *(and got things moving)*

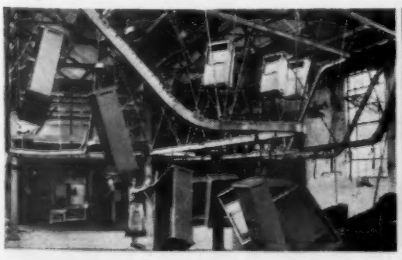
Inefficient, outdated handling methods can play havoc with production figures. They eat up the minutes, the man-hours and the money. More and more production men are becoming aware of the need for modern mechanical handling methods. If you're not happy with your present handling methods, **call in KING and get things moving.** *Our representative will call on you—anywhere in the world.*

***STREAMLINE* YOUR PRODUCTION WITH**

KING REGISTERED TRADE MARK **CONVEYORS • CRANES • PULLEY BLOCKS**

Covered by British and Foreign Patents

A KING P.C.P. LIGHT-TYPE CONVEYOR *carrying heater bodies at Valor Company's Works. For loads up to 200 lbs.*



A KING OVERHEAD TRAVELLING CRANE—*cab controlled—working with precision in a foundry.*

A KING POWER-PULLED HEAVY DUTY CONVEYOR *shown working at the Robbialac factory. For loads up to 1 ton.*

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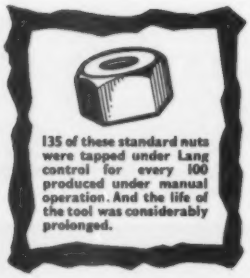
eliminates the human error

In the complex sequence operations that exist in today's industry, independent control at each function is costly in rejects due to human error; wasteful of labour; and high in overall cost.

Over 500 leading industrial concerns in this country alone have found that the introduction of Lang Pneumatic Control Gear to a great variety of precision machines and industrial functions has allowed a great use of semi-skilled labour and speeded production on precision operations. It is simple to control, has the ability to withstand heavy, continuous operation, and offers a wide flexibility of application based on standard components. Every component of Lang Pneumatic Control Gear is made from stainless steel or non-ferrous metals and is entirely non-corrodible.



135 of these standard nuts were tapped under Lang control for every 100 produced under manual operation. And the life of the tool was considerably prolonged.

LANG PNEUMATIC CONTROL GEAR entirely non-corrodible

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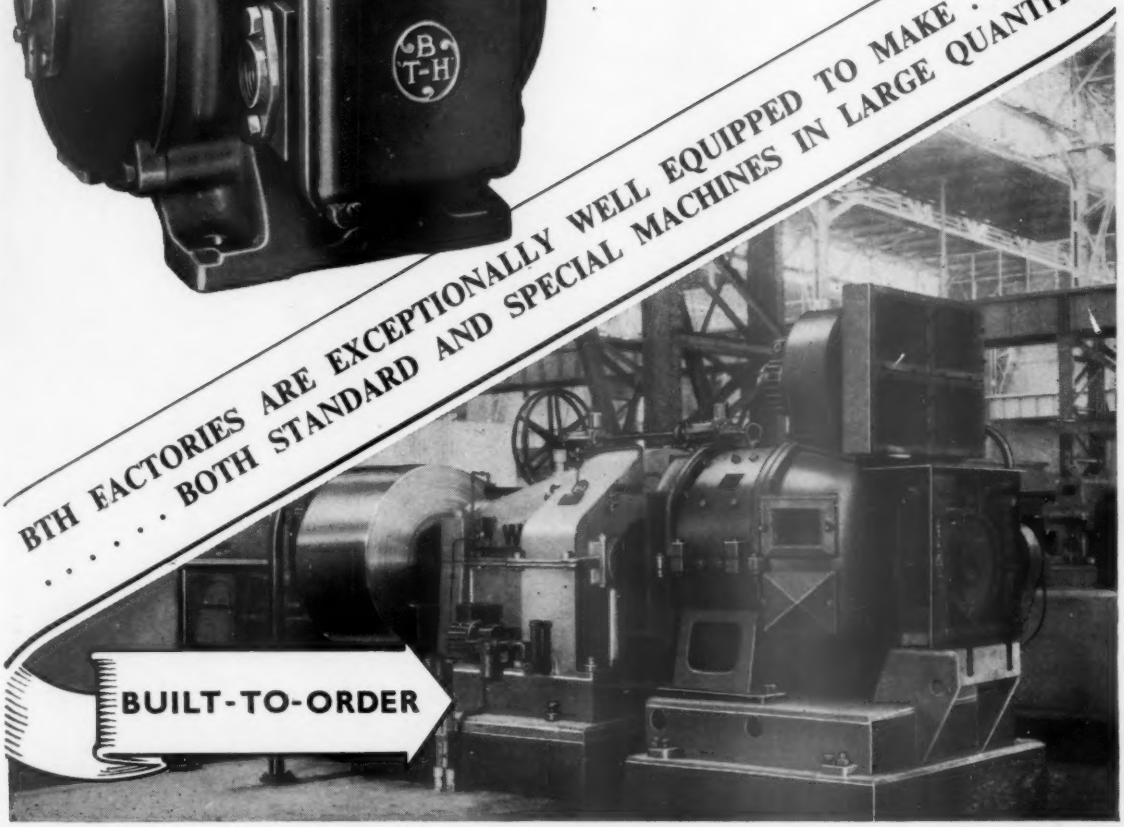
BTH FACTORIES ARE EXCEPTIONALLY WELL EQUIPPED TO MAKE . . . . . BOTH STANDARD AND SPECIAL MACHINES IN LARGE QUANTITIES



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AC or DC

No manufacturer can offer a wider choice of electric power unit than BTH whose Trade Mark is accepted by manufacturers and users as a symbol of advanced design and proved performance, with years of trouble-free service. Remember! A *BTH* power-engineer has no incentive to recommend anything but the correct motor for the job—be it 'standard' or specially built to your requirements.

THE **BRITISH THOMSON-HOUSTON** CO., LTD., RUGBY · ENGLAND

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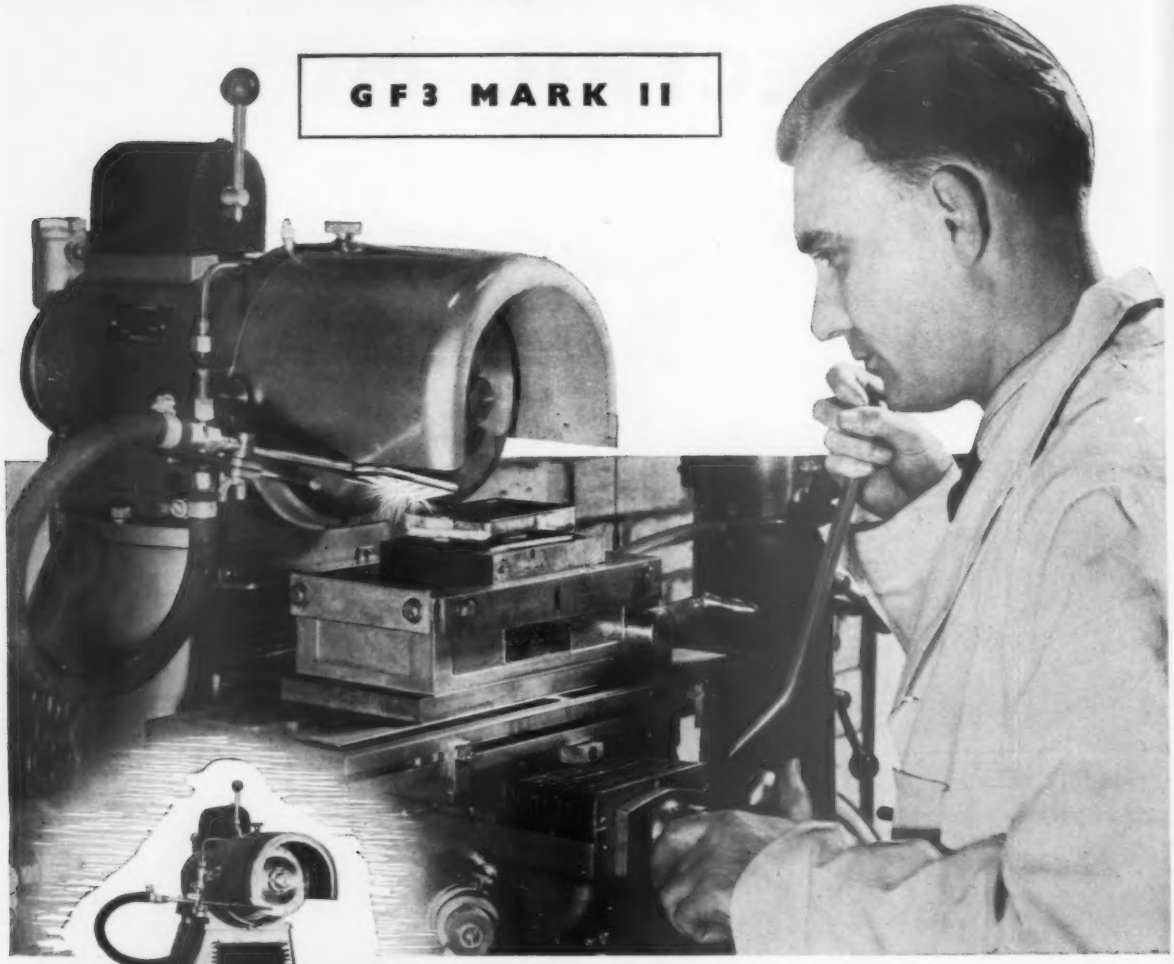
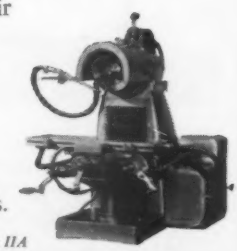
Cutting and tool grinding machine

GF3 MARK II



This bench model Universal Cutting and Grinding Machine can now be supplied in two forms, either with a manually operated traverse, or alternatively with an automatic traverse for the table. Specially designed by the manufacturers of Neven Diamond Impregnated tools for use with their products it is ideal for the tool room, laboratory or some production operations, and combines a high standard of precision with economy. Our Technical Sales staff will be pleased to arrange a demonstration or supply any further details.



Left: GF3 Mk II *Right: GF3 Mk IIA*

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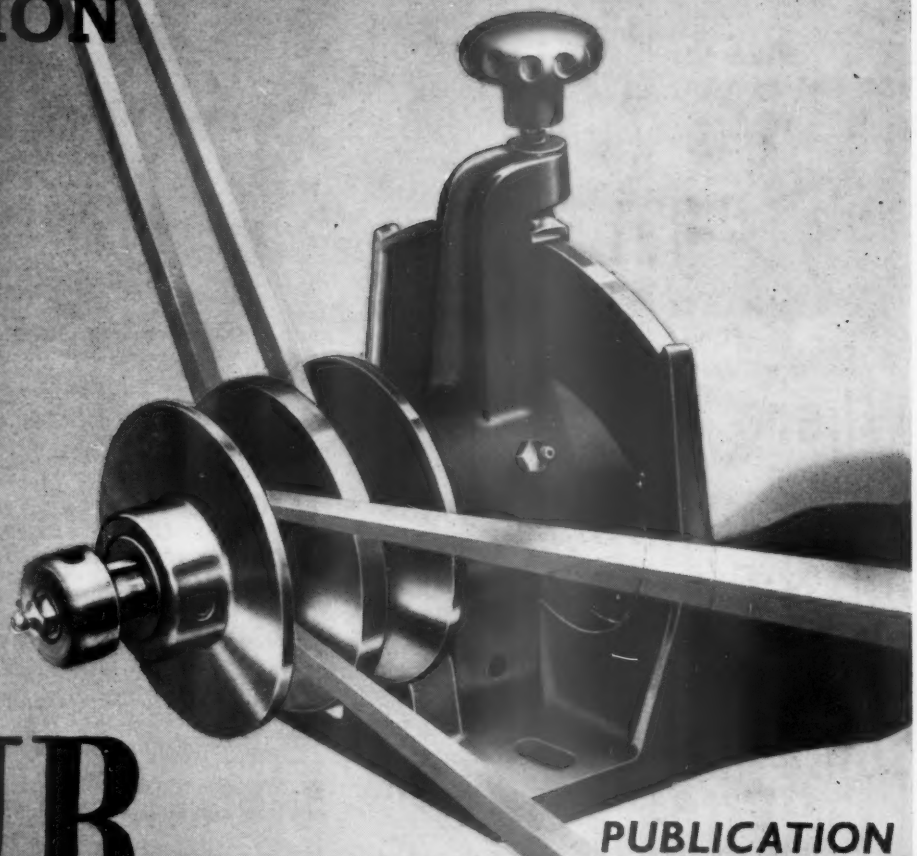

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PUBLICATION NO. 453/48

POWERS up to 10 HP
RATIOS up to 8 to 1

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We've long since ceased to be surprised at the extra-ordinary things our Stag Major Superweld tools will do —they're all so capable of outstanding performance that we can't pick just one out.

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TOOLS

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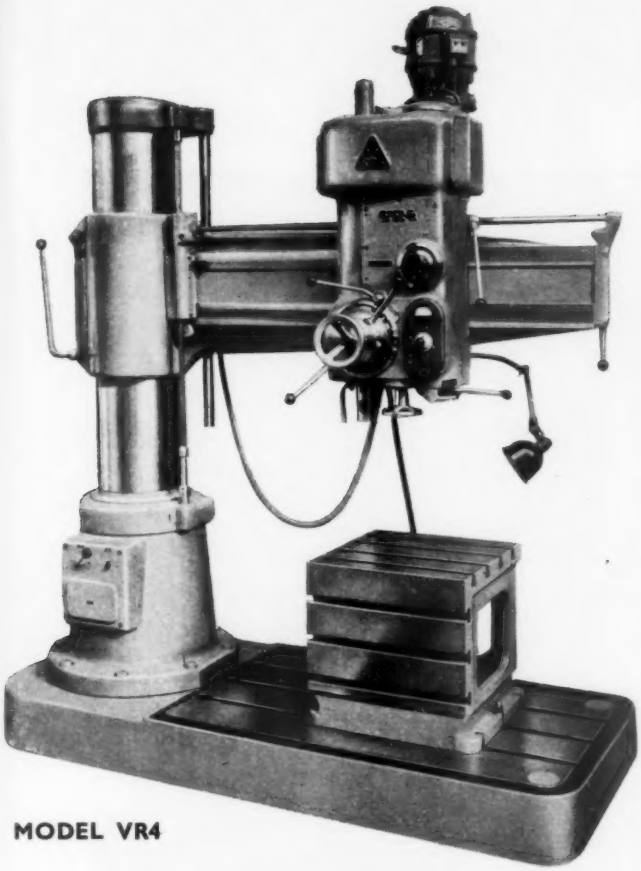

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MAS *Radial* DRILLING MACHINES

Consider these features:

- ★ Simplified and easy operation.
- ★ Patent locking of arm on column.
- ★ Automatic disengagement of power feed at required depth.
- ★ Single lever locks arm and head.
- ★ Automatic lubrication of drilling head.
- ★ Drilling speeds selected and engaged by single lever.

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SPECIFICATION	VR2	VR4	VR6	VR8
Drilling Capacity in Steel	1 in.	1 5/16 in	2 3/8 in.	3 1/4 in.
Drilling Capacity in Cast Iron	1 3/4 in.	2 in.	3 1/4 in.	4 5/16 in.
Max. distance centre line of spindle to column	31 1/2 in.	49 in.	79 in.	99 in.
Min. distance centre line of spindle to column	9 in.	12 3/16 in.	17 in.	19 1/2 in.
Max. distance spindle nose to Box table ...	24 in.	30 in.	52 in.	64 in.
Max. distance spindle nose to base	40 in.	51 in.	72 in.	83 in.
Vertical movement of arm on column ...	21 in.	28 in.	34 in.	41 1/2 in.
Taper in spindle	3 M.T.	4 M.T.	5 M.T.	6 M.T.
Spindle Speeds (12)	90-4,500	45-2,000	16-1,400	11-1,000
Spindle Feeds	(6) 85-850 cuts p. in.	(10) 16-1,020 cuts p. in.	(10) 13-820 cuts p. in.	(10) 11 1/2-720 cuts p. in.

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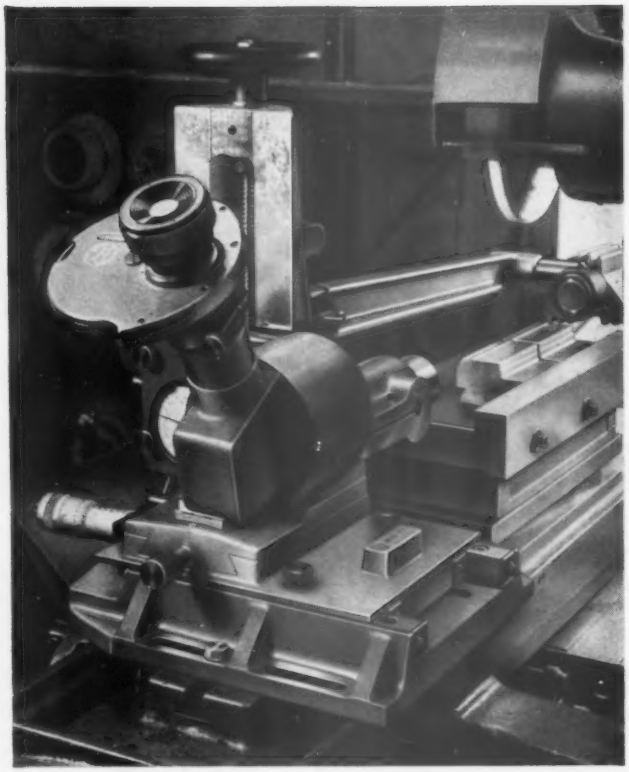

THE

PROFILOSCOPE

and the PROJECTORSCOPE

This instrument is designed on similar lines to the Profiloscope, but has a screen in place of an eyepiece. The graticule, workpiece or tool, and grinding wheel, are observed at a magnification of 25x on a 7½" dia. screen.

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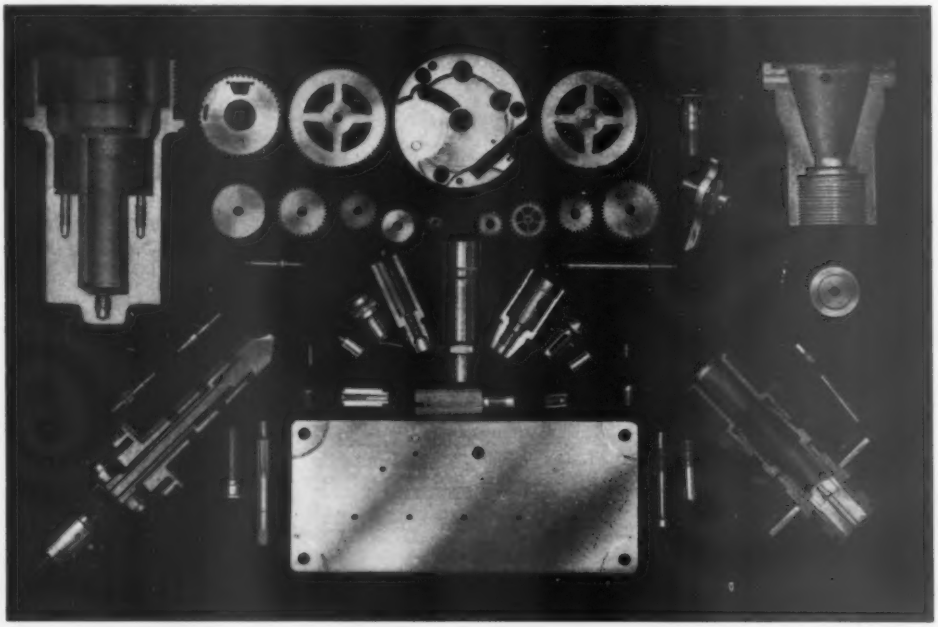

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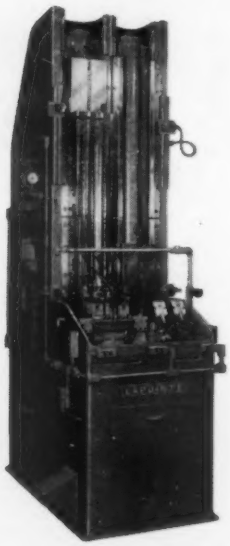
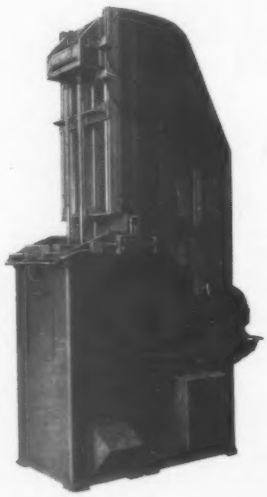


10 ton 66" D.R.V. Double Ram Surface Broaching Machine



20 ton 68" V5 Vertical Internal Broaching Machine

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the PP.96 precision surface and slideway grinding machine

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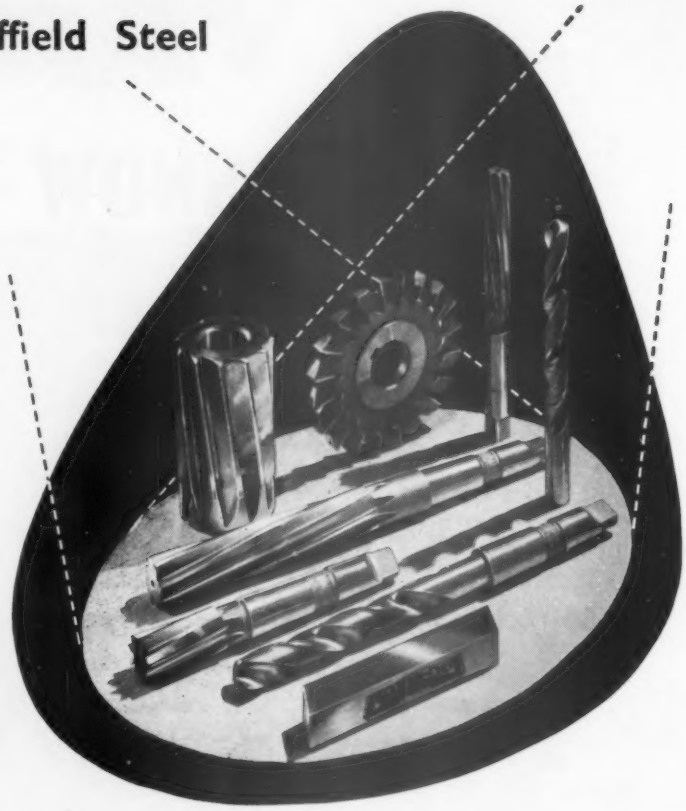

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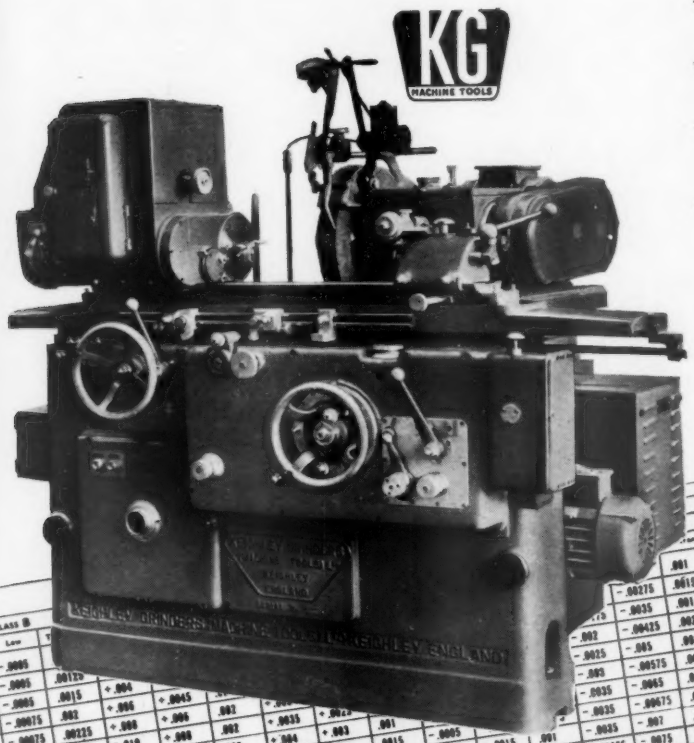

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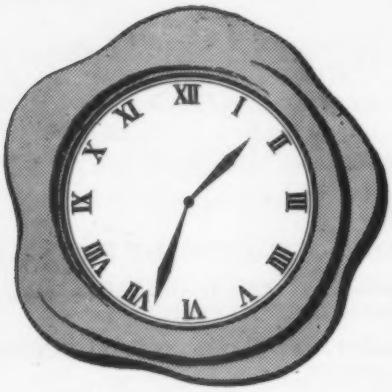

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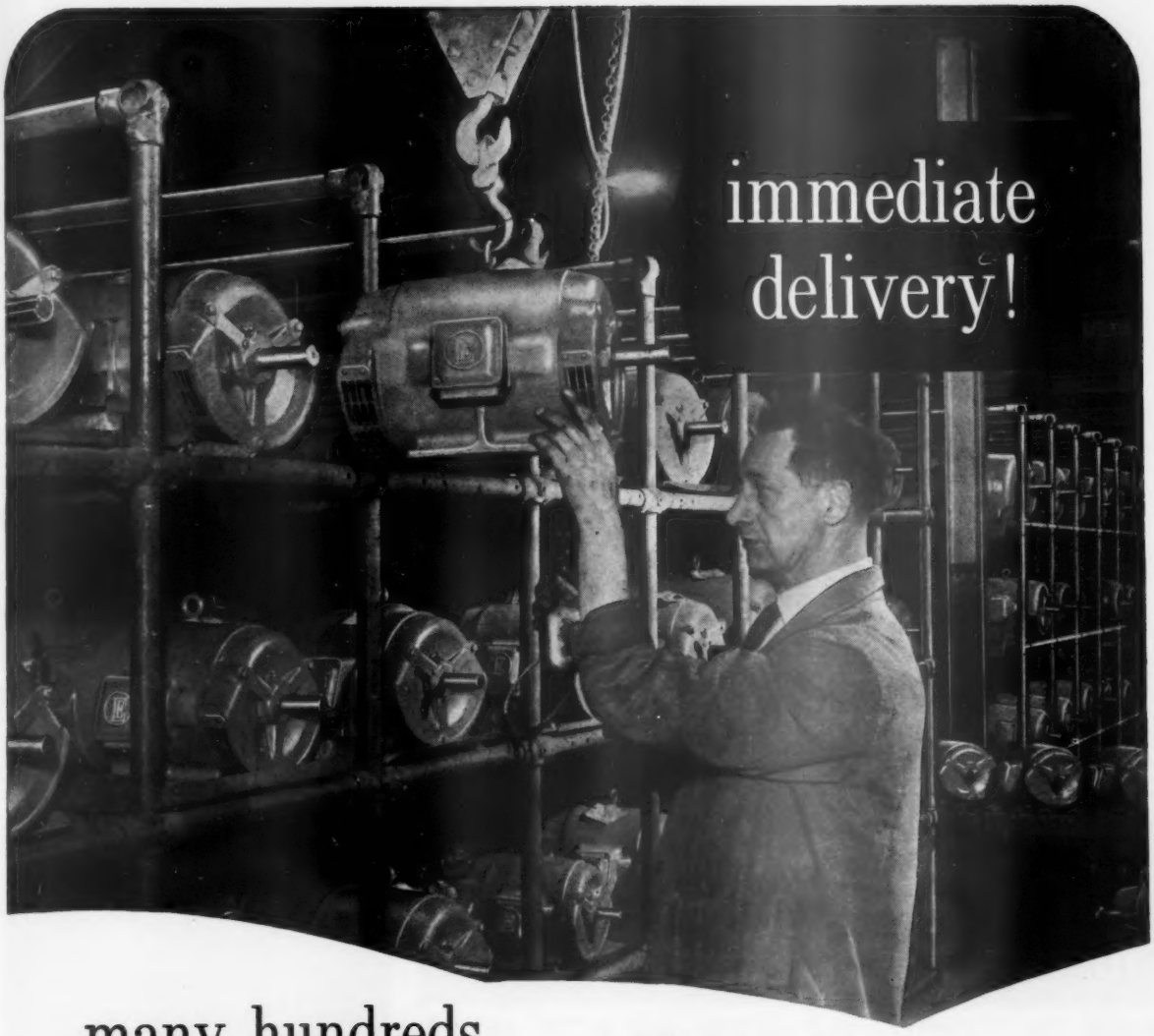

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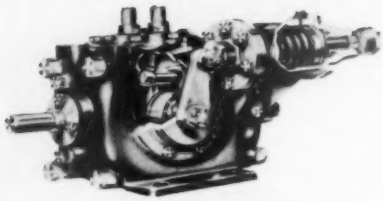

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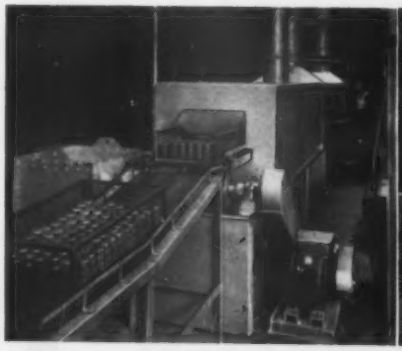
A 'Junior' type machine supplied to a Midlands Motor Car Works



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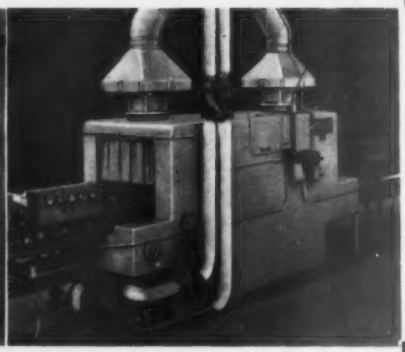
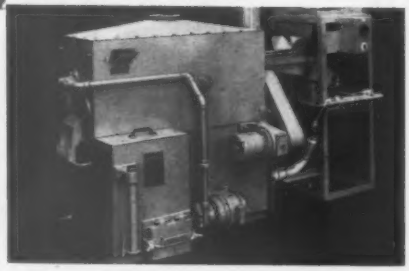


A model 'A' machine, washing parts of motor car engines prior to assembly.

Dawson

DE-GREASING MACHINES

A Rotary Drum machine for removing swarf and grease from small components.



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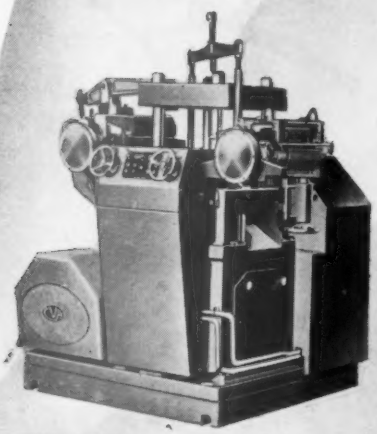
CVA Machine Tools



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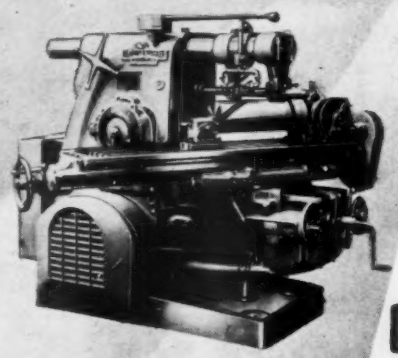
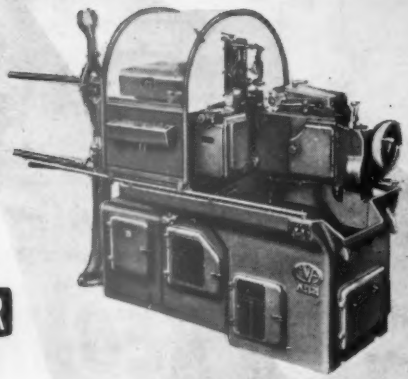
- C.V.A 50 Ton High Speed Dieing Press
- C.V.A No.12 Automatic 3/4" Cap, spindle speeds 63-5600.





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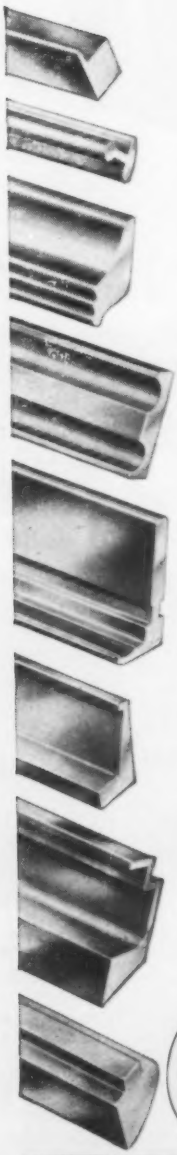

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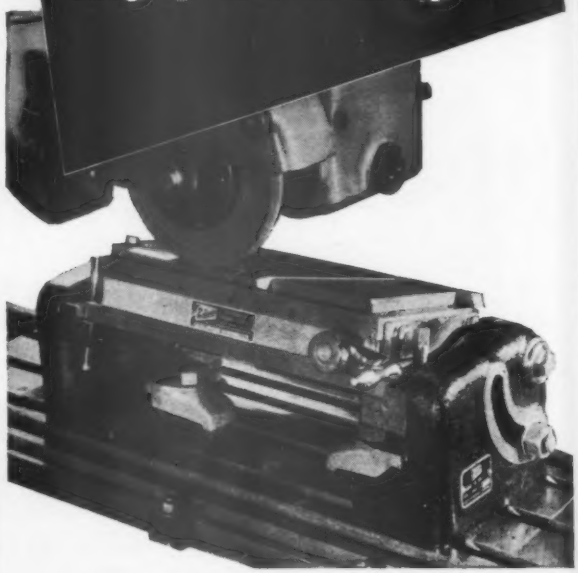

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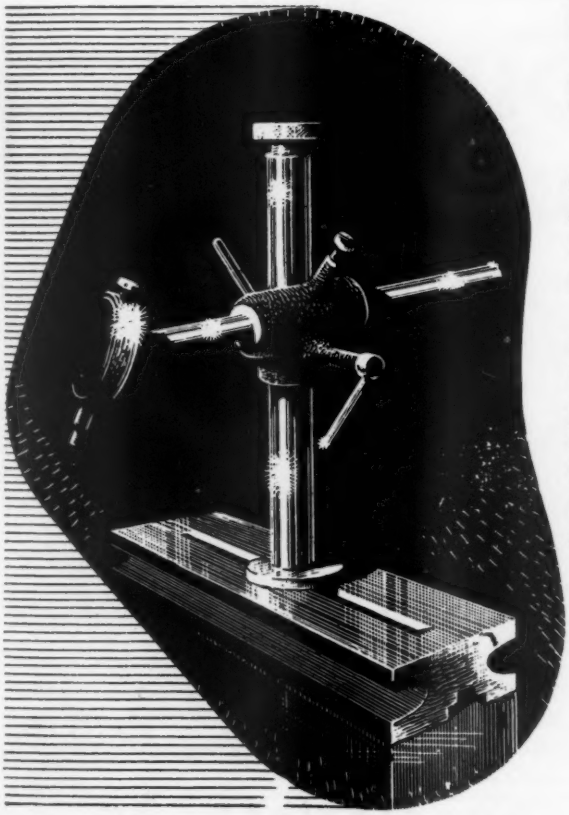

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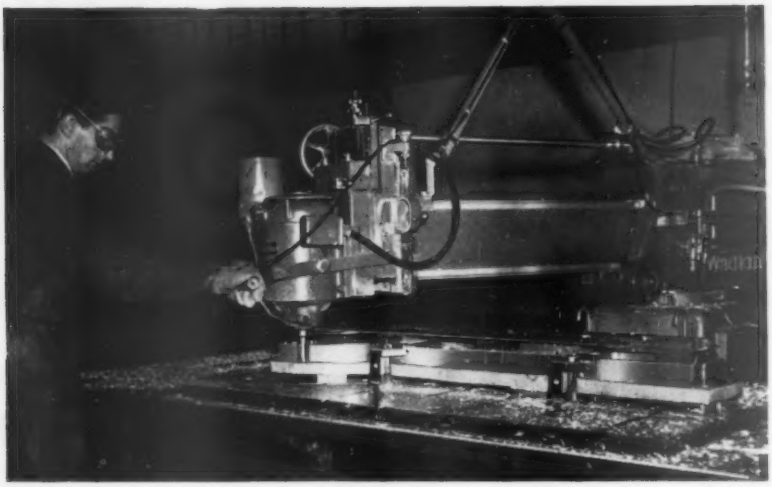

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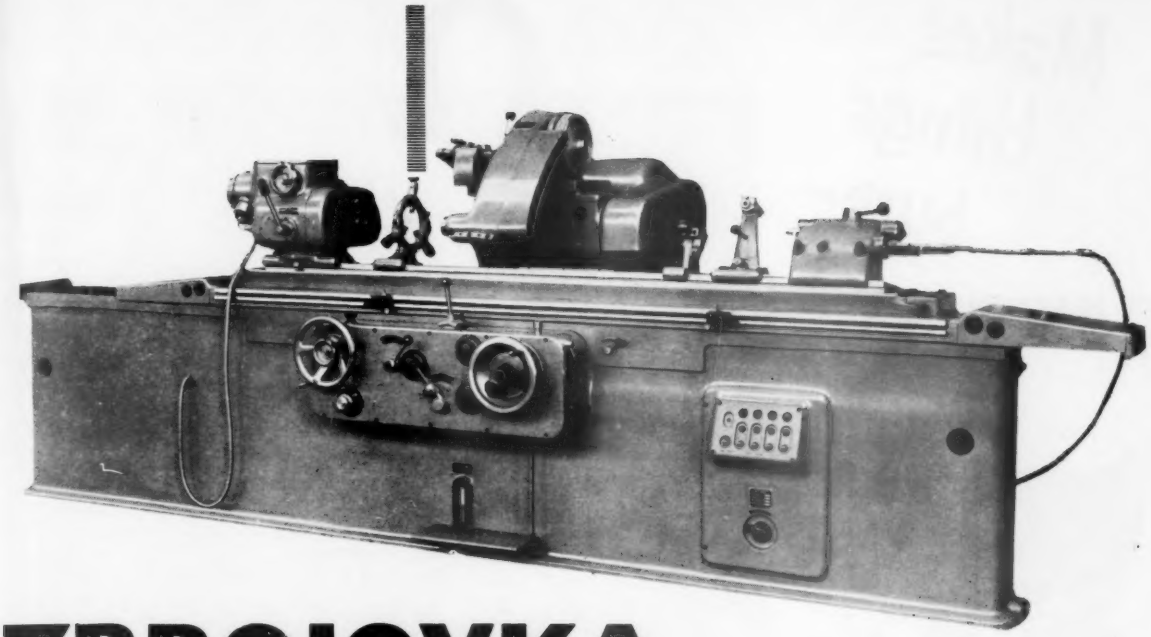

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SPECIFICATIONS	MODELS BK3		MODELS BK5		
	500	750	750	1000	1500
Height of centres over table	5⅛"	5⅛"	6 1/16"	6 1/16"	6 1/16"
Max. distance between centres	20"	30"	30"	40"	60"
Grinding wheel (dia x hole x width)	13¾"x2½"x5"	13¾"x2½"x5"	19½"x3"x8"	19½"x3"x8"	19½"x3"x8"
R.p.m. of work	50—750	50—750	25—750	25—750	25—750
Table traverse per min.	4"—19' 8"	4"—19' 8"	4"—19' 8"	4"—19' 8"	4"—19' 8"
Table swivels by	6°	6°	6°	5°	5°
Work headstock swivels by	90°	90°	90°	90°	90°
Grinding headstock swivels by	45°	45°	30°	30°	30°

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Early delivery from London stock

The Selson Machine Tool Co. Ltd

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★ *Free booklet SS638 lists the oil for each operation.*

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An electrolytic process for producing extremely hard and protective coatings on aluminium and aluminium alloys for all service conditions. The minute porosity of the film enables it to be impregnated with an attractive range of colours, which are subsequently made permanent by a special sealing process.

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An electrolytic process for producing bright reflecting surfaces on super purity aluminium. This patented process enables a transparent Alumilite anodic film of hard adherent and protective quality to be applied without loss of brilliance.

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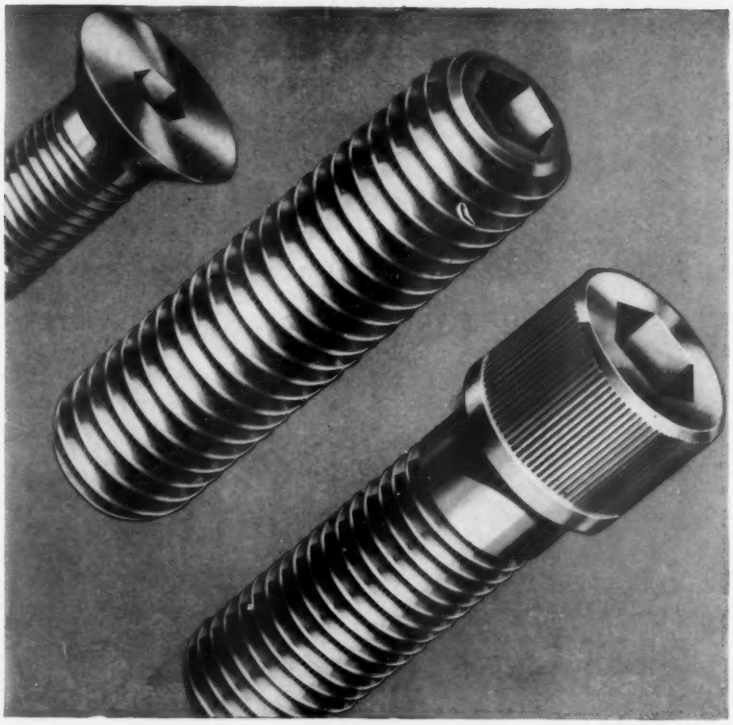

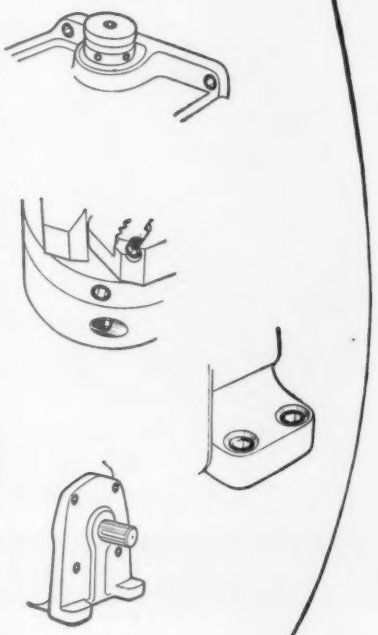

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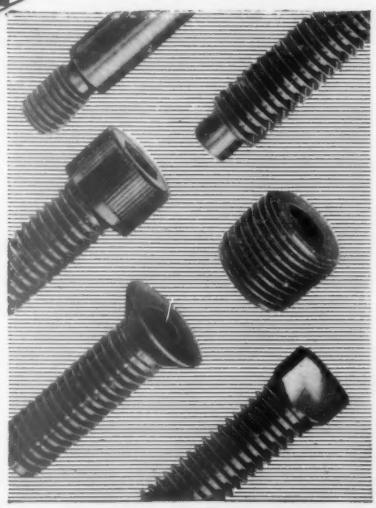

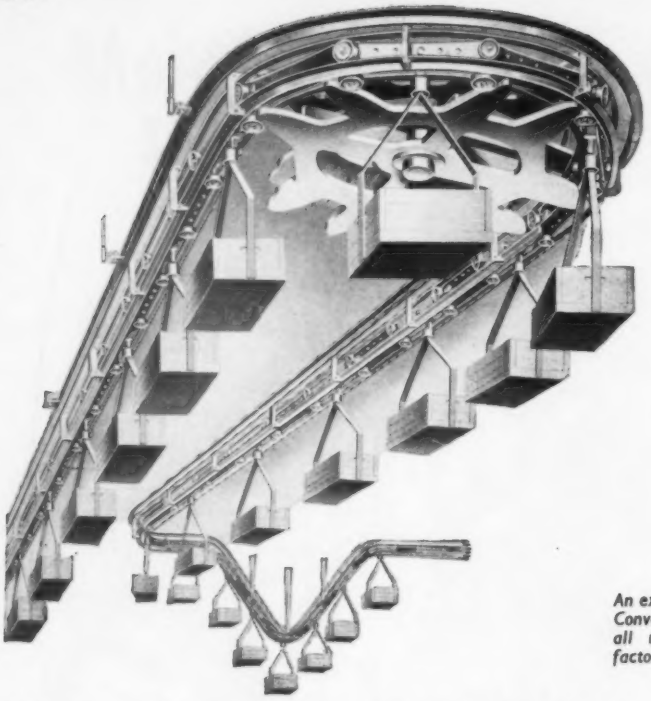

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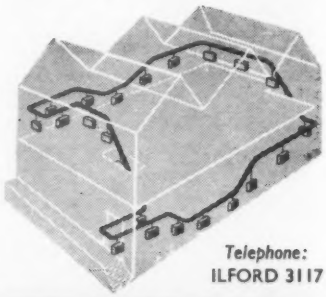
It is flexible in both horizontal and vertical planes and has full load capacity throughout the rise and fall



An example of a Teleflex Conveyor which travels all round a particular factory.

Write for illustrated Brochure Ref. I.P CON.2, March '54

Telephone: ILFORD 3117

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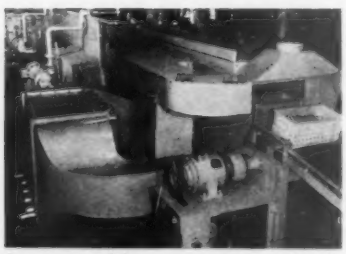
Bratby

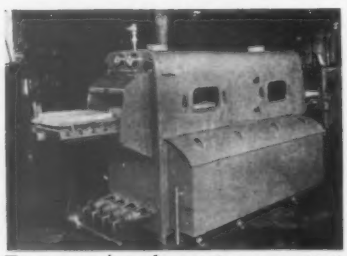
HERE ARE THREE EXAMPLES

INDUSTRIAL CLEANING MACHINES *can be designed to meet your particular cleaning problems*

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A power driven conveyor system is employed with this cleaning machine for ball bearings.



Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

Designed and Manufactured by:

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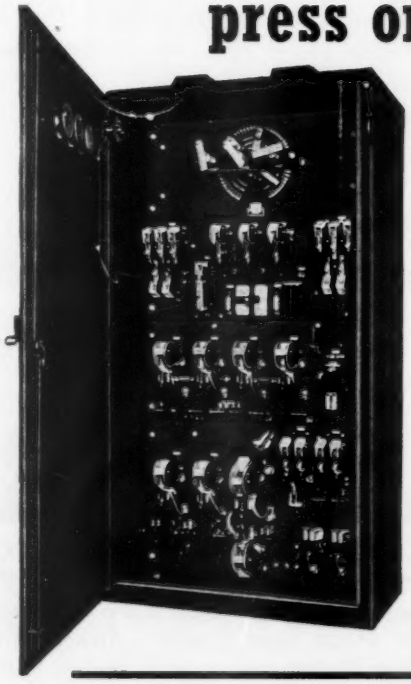
press on to greater production



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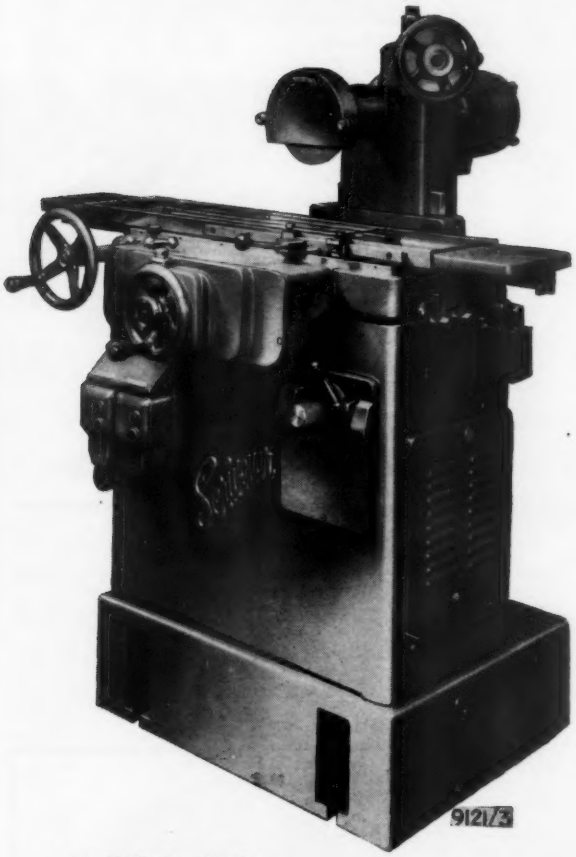
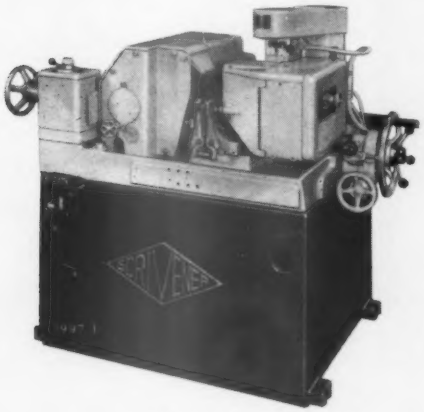
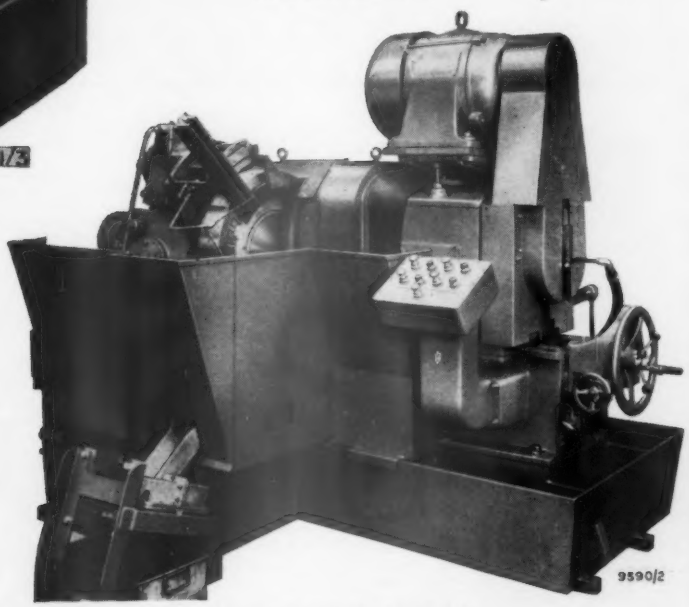


6" x 18" Surface Grinder



No. 1 Centreless Grinder



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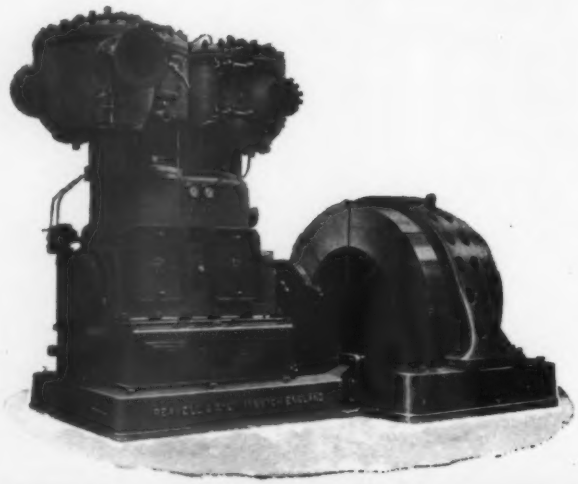

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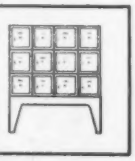
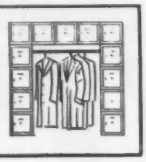
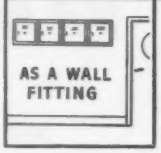


showing various arrangements





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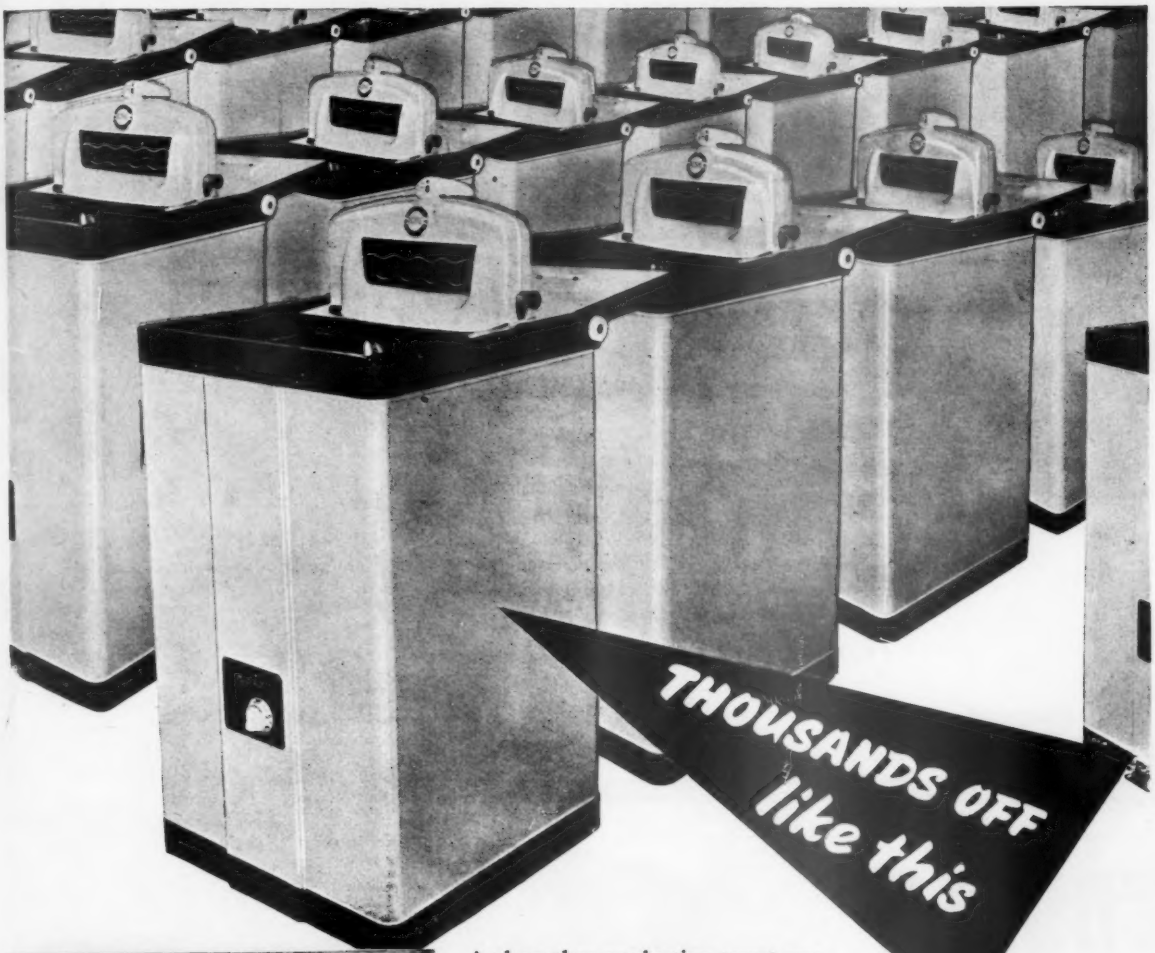

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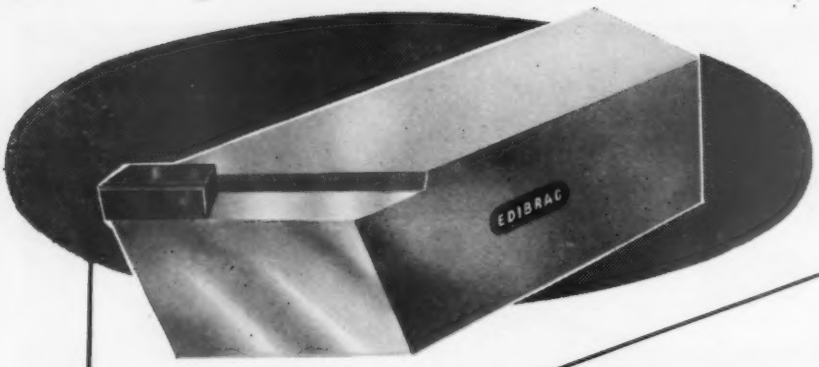

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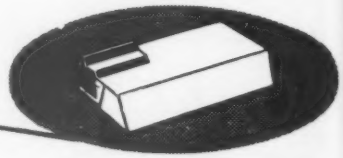

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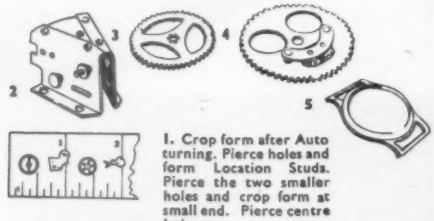

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Effective Stroke	⅞ in.	2⅛ in.

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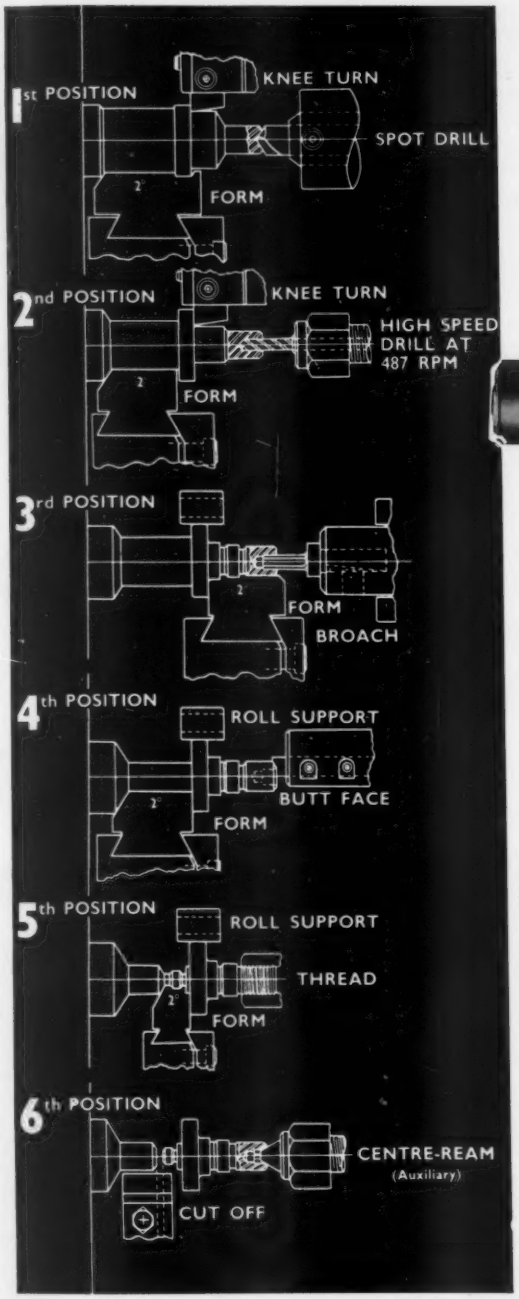

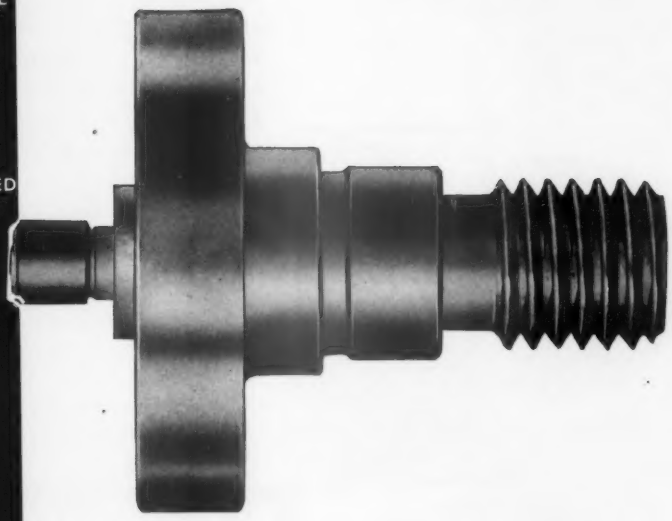

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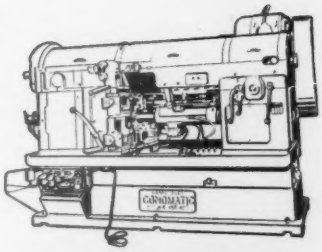

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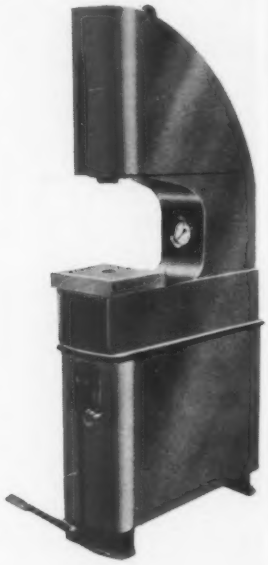

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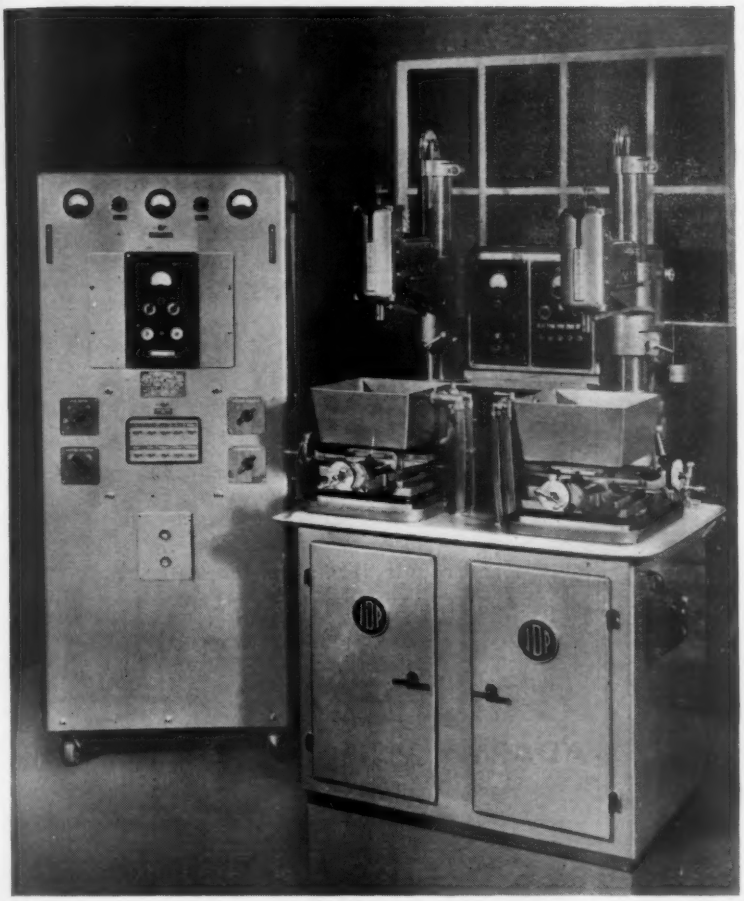

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With double head.

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The twin head model can be easily worked by one operator, and the heads operated separately, so that production per man hour is doubled.

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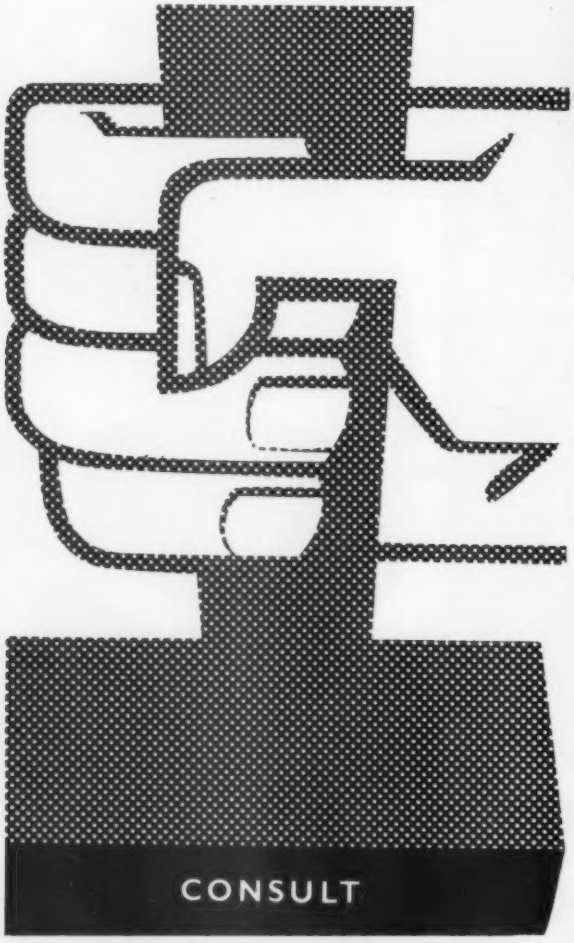

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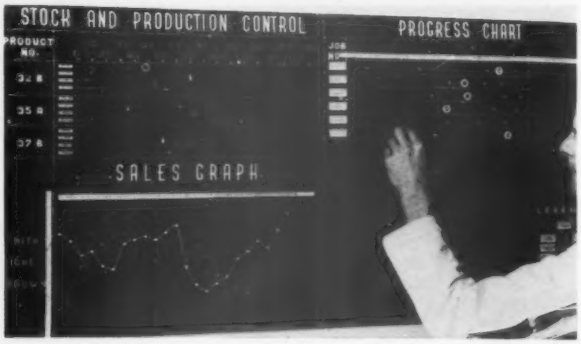

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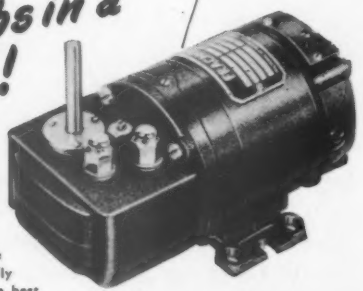

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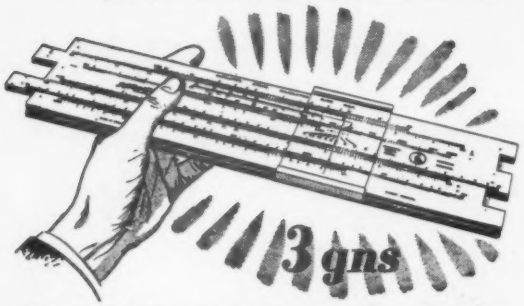

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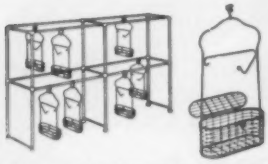

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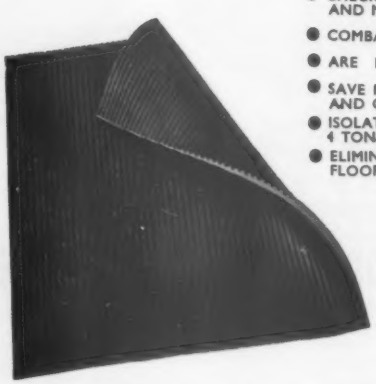

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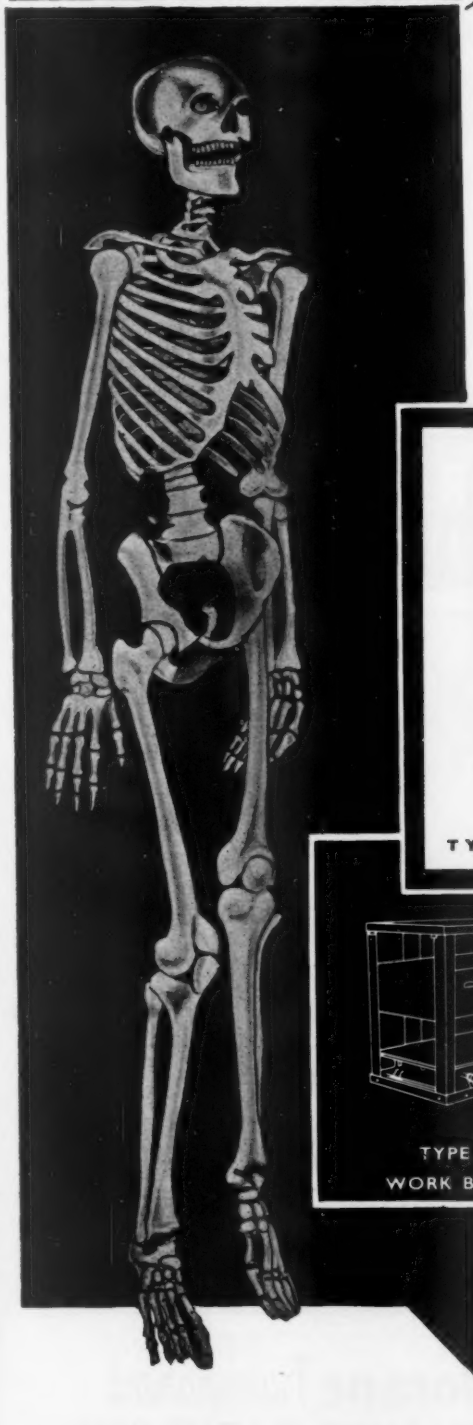

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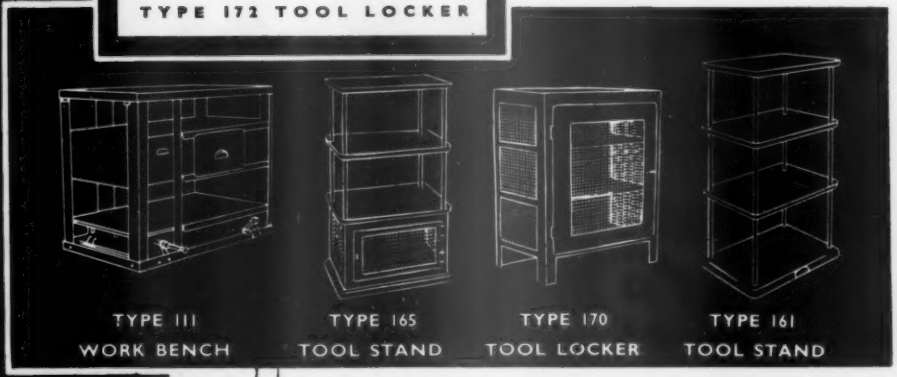

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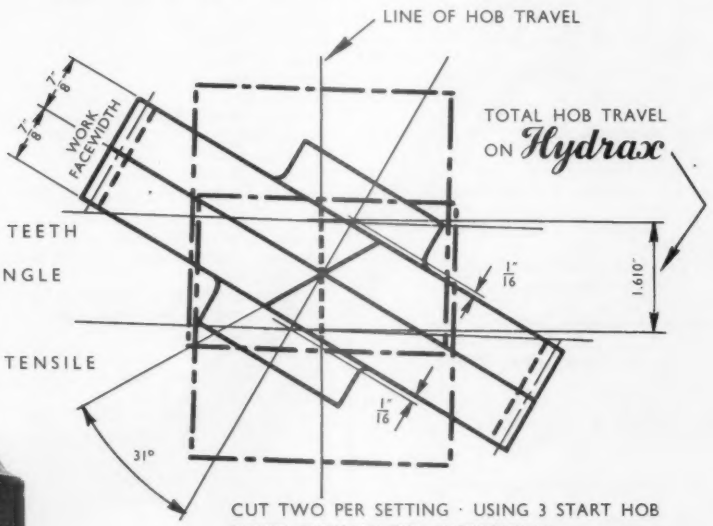

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HYDRAX FLOOR TO FLOOR TIME PER GEAR
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SHIFT AT 80% EFFICIENCY · 288 GEARS

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for

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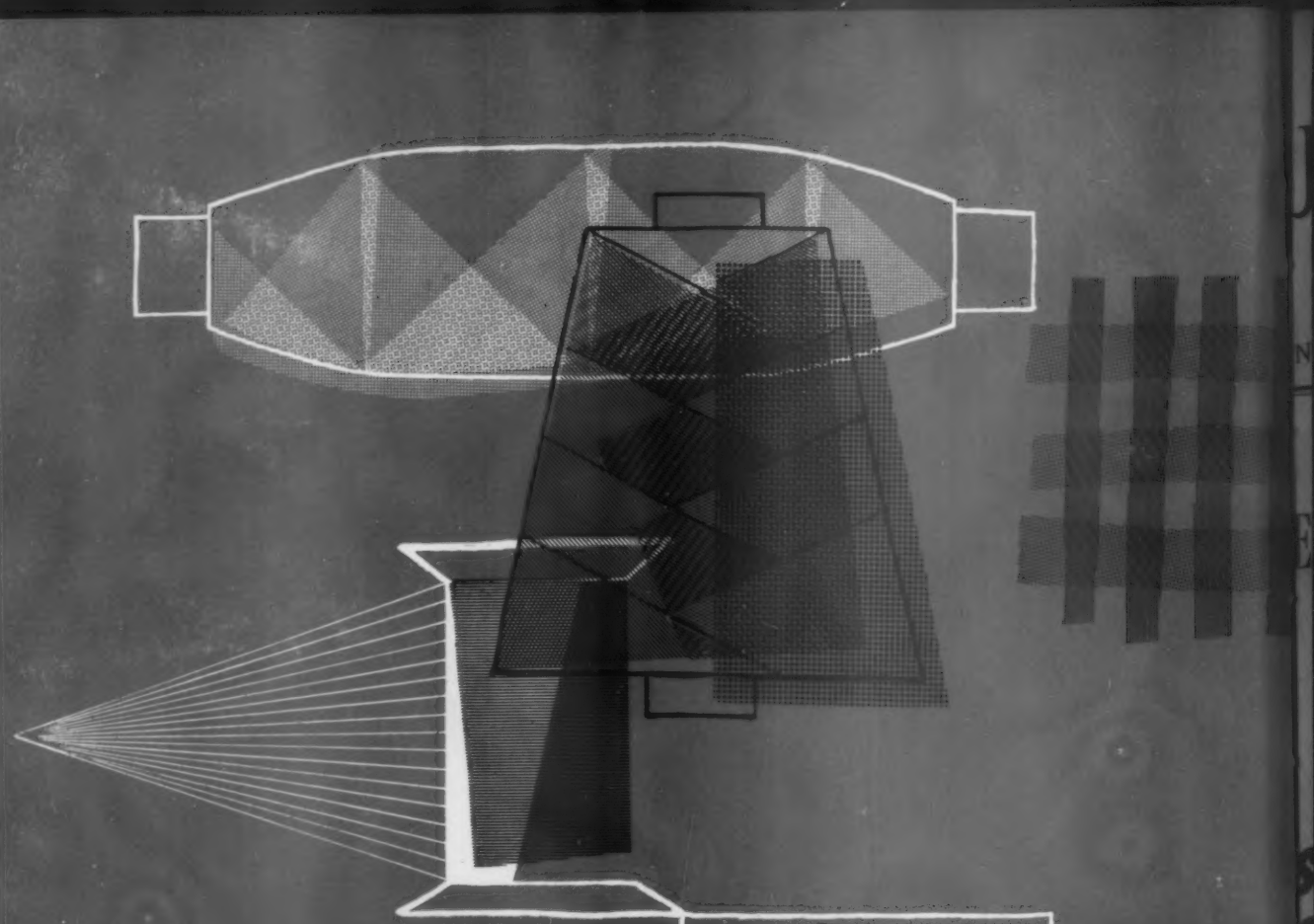

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are raising output in the

TEXTILE INDUSTRY

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JOURNAL SUPPLEMENT

Vol. 34, No. 6
JUNE, 1955

NSTITUTION OF PRODUCTION ENGINEERS, 10, CHESTERFIELD ST., LONDON, W.1

ducation for Production Management

Sixth Annual Summer School

SHORNE HILL
amington Spa

Wed. - Sun.
24th - 28th
August, 1955

The Institution has again been fortunate in securing Ashorne Hill for its 1955 Summer School. This is an ideal conference centre with a wide range of amenities and excellent accommodation—comfortable single rooms, lounges, a bar, recreational facilities and extensive grounds.

Ashorne Hill is about four miles from both Warwick and Leamington and easily reached from Birmingham, Wolverhampton, Rugby, Oxford and Coventry.

It is intended to develop the theme by envisaging future activities in industry, particularly in higher management for Production Engineering, so as to bring out future requirements in ability and technical knowledge, and thus giving educationists and students a guide as to subjects and depth of content needed.

AN APPLICATION FORM appears overleaf

SIXTH ANNUAL SUMMER SCHOOL

Theme: "Education for Production Management"

THE PROGRAMME

Wednesday, 24th August—p.m. School assembles. Opening address.

Thursday, 25th August. The opening lecture, which will be given by a representative from Industry, will survey from the industrial point of view, what Industry will look for from Education, including the future training and experience to be required for a professional production engineer.

Friday, 26th August. The second lecture, to be given by a prominent educationist, will show the contribution which the Education Services will provide in the future through courses, social training, etc., to the making of a production engineer.

Saturday, 27th August. The third and final lecture will show the pattern for the future; the development trends in industrial organization and how the young production engineer can best prepare to meet the problems arising from them.

There will be evening addresses by eminent men in Education or Industry, together with an evening visit to the Shakespeare Memorial Theatre, Stratford. After each morning lecture the rest of the day will be spent in discussion group activities, the School being divided into two Sections; those concerned with Industrial Application and those concerned with Education and Training. Each day session will close with a general forum.

A Brains Trust will be held to which members of the School will be able to address questions of general interest and particular problems which confront them in their daily work and future careers.

Fees

The inclusive fee which will cover accommodation, meals, gratuities and School course is:
Members of the Institution £9 9s. 0d. Non-Members £12 12s. 0d.

For those who wish to travel daily and who will not require sleeping accommodation or breakfast the fee is:

Members of the Institution £5 5s. 0d. Non-Members £6 6s. 0d.
(Theatre ticket is an optional extra)

Detailed joining instructions and a copy of the final programme will be sent to all those attending.

EM91/55

PRODUCTION ENGINEERING SUMMER SCHOOL 1955

APPLICATION FORM

1. I wish to attend the 1955 Production Engineering Summer School from p.m. Wednesday, 24th August, to a.m. Sunday, 28th August, and I enclose remittance (payable to the Institution of Production Engineers)

for *£9. 9s. 0d./*£12 12s. 0d. for full residential attendance
for *£5 5s. 0d./*£6 6s. 0d. for daily attendance.

2. I wish to attend the session of *The Education and Training Section/*The Industrial Application Section.
3. I *shall/shall not require garage accommodation.
4. I *do/do not wish to visit the Stratford Memorial Theatre.

NAME (Block Letters).....Membership Grade (if any).....

ADDRESS .....

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PRESENT APPOINTMENT.....

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(*Delete where inapplicable).

To: The Institution of Production Engineers,
10, Chesterfield Street, London, W.1.

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Designer Draughtsman required by light electrical engineering company in S.E. England (25 miles from London). Responsibilities cover wide variety of work from simple jigs and fixtures to substantial mechanisation developments. Pensionable post with salary up to £850 per annum. Accommodation available. Please write quoting reference K.4 and stating age, qualifications and experience to: Box W.S.9917, A.K.Advg. 212a Shaftesbury Avenue, London, W.C.2.

Tool Design Draughtsmen: Planning Engineers: Process Layout Engineers. Hoover (Washing Machines) Ltd., Merthyr Tydfil, S. Wales, invite applications from suitably qualified persons for the following posts in the Production Engineering Department. Applicants should be experienced in modern mass production techniques: 1. **Tool Design Draughtsmen.** Experience desirable of press tools, jigs and fixtures, or dies and moulds. Practical experience of machine shop practice an advantage. 2. **Planning Engineers.** Experience desirable of press work and precision die-casting. Practical experience of machine shop practice an advantage. 3. **Process Layout Engineers.** Practical experience of machine shop practice an advantage. Assistance with housing can be offered in certain circumstances. Applications, containing fullest details of qualifications, experience, education and age, should be addressed to: the Employment Officer.

Refrigeration Product Engineer: Quality Control Engineer: Process Engineer. Kelvinator of Canada Limited, Manufacturing Division, London, Ontario, has vacancies for:- Refrigeration Product Engineer. Quality Control Engineer. Process Engineer, and would welcome applications from suitable qualified men who have decided to emigrate to Canada. Working conditions are among the finest in Canadian industry and prospects are outstanding. Attractive salaries including group insurance coverage plan for medical, hospital and weekly indemnity for employees and eligible dependents, sick leave policy, life insurance, pension, vacations, five-day week. Applications should be addressed in the first instance to: Ontario Government, Immigration Office, 12 New Burlington Street, London, W.1, from whom information and advice can be obtained.

Methods Engineer required for interesting progressive post in Capacitor firm in S.W. London. Previous capacitor experience not necessary but training to O.N.C. standard is desirable. Please write giving details of experience, age and salary required to: Box No. 1112, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Chief Planning & Production Engineer. Precision engineering Company of standing is seeking man of highest calibre, having qualities of leadership, for appointment to a position offering, along with substantial remuneration, substantial scope for advancement. Applicants should be aged about 35, possess comprehensive practical machine shop experience and be thoroughly conversant with planning, processing, ratefixing and designing of jigs, tools and fixtures for small batch quantity work in light/medium precision engineering. Apply, giving in confidence details of personal and industrial history to: Personnel Manager, Molins Machine Co. Ltd., Evelyn Street, London, S.E.8.

Chief Jig and Tool Designer required by reputable manufacturing engineering company in London. Applicants for this progressive and remunerative position should be aged 35-40, possess comprehensive practical tool-room experience and be thoroughly conversant with designing of jigs, tools and fixtures for light/medium precision engineering. Apply, giving in confidence details of personal and industrial history to: Personnel Manager, Molins Machine Co. Ltd., Evelyn Street, London, S.E.8.

Machine Tool Designer conversant with design of cam operated metal cutting machines. Applicants must be capable of designing complete machines from general specification of capacities and description of mechanism to be utilised. Excellent opportunity with first class well-known Company. All applications will be treated with strictest confidence. Please apply stating full experience, age and salary expected to: Box No. 1113, I.Prod.E., 10 Chesterfield Street, London, W.1.

Process Planning Engineers, Senior and Junior Jig & Tool Draughtsmen, Methods Engineers. Rotax Limited, Hemel Hempstead, have the following vacancies: Process Planning Engineers, Senior and Junior Jig and Tool Draughtsmen to deal with the planning and tooling of precision electrical and mechanical aircraft equipment. Methods Engineers for machine shop precision light engineering aircraft electrical and mechanical equipment. Good general experience of modern production engineering technique essential. These positions are superannuated and give ample opportunity for promotion. Successful applicants will have the opportunity of renting a small modern house or flat in the New Town and preference will be given to candidates who are on an approved housing list in the Greater London area. Applications should be made in writing, giving full details of qualifications and experience, to: the Personnel Manager, Rotax Limited, Maylands Avenue, Hemel Hempstead, Herts.

Time & Motion Study Engineer to take charge and reorganise the Time Study section of a modern engineering works engaged in the machining and assembling of automobile components. Only engineers having had at least five (5) years experience in scientific time and motion study need apply. Salary £900-£1,000 in accordance with experience. This is a permanent staff appointment, pensionable, and with opportunities for advancement for an experienced and ambitous engineer. Factory located 30 miles North of London where rented housing accommodation is available. Box No. 1114, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Production Engineer required for medium sized light engineering factory. Duties would involve the control, under the Production Engineer, of time and motion study, jig and tool design, work study and service departments. Salary £800/1,000 according to qualifications. Box No. 1115, I.Prod.E., 10 Chesterfield Street, London, W.1.

Estimating Engineer required in expanding organisation. Applicants should be between 35/40 years of age, have a H.N.C. in mechanical or production engineering, and preferably have experience of the telephone or electronic industry. Apply: Personnel Officer, Airmec Limited, High Wycombe, Bucks.

Technical Representative. Scottish Precision Machine Tool firm of repute wish to appoint a Technical Representative to cover the Northern half of England. He would be required to install and demonstrate new machines, advise on cutting problems and carry out servicing of machines in customers Works. Car provided and expenses paid. Pension scheme in operation. Apply in writing stating qualifications, experience and salary required to: The Secretary, Messrs. John Lang & Sons Ltd., Johnstone, Renfrewshire. Applications will be strictly confidential.

Time Study Engineers. Applications are invited for positions as Time Study Engineers with a progressive light engineering company in the West Middlesex area who are members of a large group of engineering companies. Applicants should preferably have a good workshop training and, although a knowledge of time study is desirable, training will be arranged for by the Company for suitable applicants without present experience. Apply to: Personnel Officer, Bryce Berger Limited, Ironbark Works, Staines, Middlesex.

Work Study Engineer required to initiate and maintain a new department in a medium sized factory engaged upon repetition woodworking. Applicants must be technically qualified and have an original approach. Commencing salary £900/£1,000 per annum according to ability. Applicants should state age, and full details of experience, in confidence to: the Managing Director, H. Massil & Sons (Woodturners) Ltd., Welham Green, Hatfield, Herts.

Manager. First class practical engineer, age 40/50, for large N. West engineering works engaged on medium to light products, to be responsible to General Works Manager, as manager of the largest main works division, employing 1,800. The responsibilities cover normal manufacturing functions over batch production on a very varied, modern plant, sub-assembly and assembly shops. Labour relations are good. Emphasis is on a commonsense practical ability to use efficiently first class plant; a wide experience in machine tool, or allied engineering, an advantage. Preference will be given to a practical shop background, and experience in handling men and machines, rather than to technical office experience. The position, intended to be permanent, carries a commensurate salary, with generous pension scheme. Box No. 1116, I.Prod.E., 10 Chesterfield Street, London, W.1.

Planning Engineers required, must have previous experience of production planning in medium light electro mechanical engineering field. Salary commensurate with ability. Please apply: The Personnel Manager, Messrs. Elliott Bros. (London) Ltd., Airport Works, Maidstone Road, Rochester, Kent.

Planning Engineer and two Assistant Planners required for heavy engineering Works situated in the South West of England. The work entails process planning and ratefixing on small and medium batches covering production in machine shops, fitting and erecting shops. Applications giving details of experience, age and salary required to: Box No. 1117, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Mechanical Engineer required by well-known Electronic Engineering Company. Must have had considerable experience of mechanical design, process planning, tool design and estimating in connection with electronic equipment. Chartered mechanical or electrical engineer preferred but not essential. This is a responsible position and a commensurate salary will be paid to the successful applicant. Write giving full details of experience and present salary to: Personnel Officer, Airmec Limited, High Wycombe, Bucks.

Technical Assistant for technical service work connected with lubrication in all aspects in the general engineering industry. Experience in modern production methods and surveying of factories favoured. Applicants required to travel. Write to: Technical Service Manager, Alexander Duckham & Co. Ltd., Thames Wharf, Hammersmith, W.6, stating experience and salary required.

Production Control. Assistant to Production Control Manager required by old established firm of engineers, North-West Birmingham. The post offers excellent prospects to a young man possessing engineering degree or Higher National Certificate and previous experience in production control. Applicants should not be less than 26 years of age and have completed National Service. Applications giving full details of education, experience and age should be addressed to: Box No. 1118, I.Prod.E., 10 Chesterfield Street, London, W.1.

Technical Sales Office. Assistant to deal with commercial correspondence involving technical detail. Negotiation with customers visiting showrooms and exhibitions. Engineering background with knowledge of engineers' measuring equipment or surveying instruments. Apply: Personnel Officer, Hilger & Watts Ltd., 48 Addington Square, London, S.E.5.

The Government of Pakistan invites applications for the following posts in the Explosives Group of the Ordnance Factories in Pakistan.

Works Manager—1. To take charge of Workshops employed in the production of small arms, gun ammunition, and other contingent stores. Experience in accurate repetition work is essential. Candidates must be Associate Members of the Institution of Mechanical Engineers or hold equivalent qualifications and have had experience in the control of labour. **Works Manager—1. (Production, Planning & Progress).** Candidates must have had appreciable experience in the responsible control of a Production Department in a large Factory, preferably one which produces or has produced arnaments. Qualifications must include a University Degree in Engineering or at least Associate Members of an appropriate Professional Institution. **Assistant Works Manager.** Shell Forge & Machining—1. Candidates must have a knowledge of high frequency induction method of heating of billets together with experience in the operations for the forging of service projectiles. A knowledge of the subsequent machining operations is also desirable. **Shop Manager.** Miscellaneous Machining & Press shop—1. Candidates should have had practical experience in the production of small arms, and other contingent armament stores: should also have had a wide and controlling experience of medium size single and double action power press work and other machines as used in the production of pressed components for warlike stores and subsequent assembly by welding.

Drawing Office Staff for Chief Engineer's Department. Chief Draughtsman (Assist. Works Manager)—1. **Senior Draughtsman (Shop Manager)**—1. **Leading Draughtsman (Section Officer)**—3. Required for the Department of the Chief Engineer concerned with installation and maintenance of all kinds of engineering plant and machinery and associated services.

Drawing Office Staff for Production Engineer's Department. Chief Draughtsman **(Asst. Works Manager)**—1. **Senior Draughtsman (Shop Manager)**—1. Required for Duties which are mainly jig and tool design.

Rates of Pay:

Works Manager: Rupees 850-100-1,550 per month plus £30 Sterling per month overseas allowance from date of embarkation plus a Technical staff allowance as authorised on arrival in Pakistan.

Assistant Works Manager: Rupees 600-50-1,000 month plus £25 Sterling per month overseas allowance from date of embarkation, plus a Technical staff allowance as authorised on arrival in Pakistan.

Shop Managers: Rupees 540-30-660-680-30-800 per month plus £25 Sterling per month overseas allowance from date of embarkation plus a Technical staff allowance as authorised on arrival in Pakistan.

Section Officer (Foreman). Rupees 500-20-840-855 per month plus Rupees 75 from date of embarkation plus a Technical staff allowance as authorised on arrival in Pakistan.

Forms of application may be obtained by application, *in writing*, to the Co-Ord Officer for Factory Recruitment, Office of the High Commissioner for Pakistan, 39, Lowndes Square, London, S.W.1. Closing date for applications, 25th June 1955.

Planning Engineers. A number of vacancies for both Senior and Junior engineers of proved ability who have specialised in either (a) machine shop work or (b) sheet metal work. Applicants should have a sound practical knowledge based on extensive shop experience in the aircraft engine or similar industry. Please write, giving full details of experience and education to: The Personnel Officer, The De Havilland Engine Company Limited, Leavesden, Nr. Watford, Herts.

Work Study or Methods Engineer required with previous experience of time study in precision engineering. Age 35 to 40. Apply stating age, experience and salary required to: C. E. Johansson Limited, Southfields Road, Dunstable, Beds.

Additional Consultant required to complete small group acting in advisory capacity to Directors of large organisation on Merseyside. The field of operations ranges from medium-light engineering to very large scale clerical procedures. The work involves a review of organisation, administration, and methods, throughout the group, and the introduction of work study, planning, financial control and all the tools of modern management. A good general education; a degree or other professional qualification in engineering, and at least two years experience in work study, preferably in conjunction with Industrial Consultants, are desirable. This post offers exceptional opportunities to a relatively young

man of ambition and proved ability and the initial salary will be in accordance with the experience of the successful applicant. Box No. 1119, I.Prod.E., 10 Chesterfield Street, London, W.1.

EDUCATIONAL APPOINTMENTS

Wolverhampton and Staffordshire Technical College.
Research Assistants. Vacancies exist in Department of Production Engineering & Management for full-time Research Assistants, to pursue projects on surface finish, mechanics of metal cuting and forming, tool stress measurement, metrology and other problems. Preliminary training will be given in research principles and methods including scientific literature source studies. Opportunities for demonstration and lecturing up to a maximum of 6 hours per week. Appointments will be for two years. Salary £500-£550. Applications from graduates or persons possessing equivalent qualifications should be made on forms obtainable from: G. W. R. Lines, Clerk to the Governors, Education Offices, North Street, Wolverhampton. (Stamped addressed envelope).

Grantham College for Further Education, Avenue Road, Grantham.
Full-time Teacher of Engineering. Application are invited for appointment to the post of Full-time Teacher of Engineering. The duties of this post may be concerned with part-time, day and evening, courses in some of the following:- Ordinary National Certificate in Mechanical Engineering. Higher National Certificate in Mechanical and Production Engineering. City and Guilds in Machine Shop Engineering. The salary offered is according to the Burnham Technical Scale A. Applicants should hold some recognised degree, diploma or other professional qualification. Ability to assist with general college activities will be a recommendation. The appointment will date from 1st September, 1955. Application forms, and other particulars, may be obtained by sending a stamped addressed envelope to the Principal. Completed forms should be forwarded immediately, and in any case not later than two weeks after the appearance of this advertisement to the Principal, Grantham College for Further Education, Avenue Road, Grantham.

Northampton Polytechnic, London, E.C.1.
Lecturers for full-time permanent, pensionable staff required to instruct students in (a) Instrument Engineering and (b) Production Engineering. Requirements are H.N.C. or equivalent and some industrial experience. Salary on Burnham London Scale according to qualifications and experience: Minimum £486 (plus £60 if graduate) rising to at least £773. Particulars and form of application from Secretary.

Slough College of Further Education.
Grade A Assistant. Applications are invited for the appointment of Grade A Assistant to teach engineering workshop subjects. Candidates should hold a Final City and Guilds Certificate in Machine Shop Engineering or an equivalent qualification. Further details and forms of application may be obtained from the Principal, College of Further Education, William Street, Slough, to whom they should be returned as soon as possible.

Bolton Technical College.
Assistant Grade B. Applications are invited for the position of Assistant Grade B, in the Mechanical Engineering Department, to teach some or all the subjects Machine Tools, Jig and Tool Design, Production Planning and Industrial Administration to Higher National Certificate standard. Some knowledge of Work Study would be an additional recommendation. Candidates must have a good industrial background, and teaching experience is highly desirable. It is hoped that the successful applicant will be able to take up duties on 29th August. Salary will be in accordance with the Burnham Technical Scale, viz. Grade B £525 x £25 to £820 per annum. Up to 12 increments may be allowed for approved industrial experience plus additional allowance for degree or equivalent and training. Application forms and further particulars may be obtained from the Chief Education Officer, Education Offices, Nelson Square, Bolton, to whom the completed applications should be returned within 10 days of the appearance of this advertisement.

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Purchase Manager, required by International organisation specialising in automotive transmissions. Excellent opportunity for present assistant Chief Buyer with automobile experience to carry full responsibility. Modern factory, Hertfordshire: Superannuation, welfare schemes. Applications stating age, marital status, qualifications, availability and present salary to: Box No. 1100, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Inspector fully experienced in mass production of automotive transmissions required by International organisation. Ability to organise and control inspectorate staff and set quality standards. Excellent opportunity for person with experience plus imagination to advance with team of keen executives. Modern factory, Hertfordshire: Superannuation, welfare schemes. Applications stating age, marital status, qualifications, availability and present salary to: Box No. 1101, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Works Manager aged 28-38 required by leading precision instrument manufacturing company with modern factory in Kent. Applicant should have good shop floor experience mainly on light assembly and finishing, ability to organise and control approximately 100 employees, to introduce through foremen improved manufacturing methods, to operate production programmes and to maintain discipline. Successful applicant will be eligible for rapid promotion. Starting salary about £1,000 per annum according to qualifications. Contributory pension scheme. Reply stating age, education, previous earnings and positions held in confidence to: Box No. 1087, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer. First class work study man required by progressive company operating in North London. Must be fully trained in all aspects of work study, and capable of initiating a Work Study Department. Good salary and prospects. All correspondence will be treated in confidence. Apply: Box No. 1104, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study. A vacancy exists for a man experienced in work study required for the work study department of a group of companies situated in the Slough area. Must be fully experienced in time and motion study methods and methods engineering. Write giving full particulars of previous experience to: Box No. 1105, I.Prod.E., 10 Chesterfield Street, London, W.1.

Automation. Experienced Jig/tool and/or Machine Designer required by progressive engineering company in the West Country employing 250 engaged in the mass production of automobile assemblies. This vacancy offers an unique opportunity for an ingenious designer to work on his own initiative to carry out the automation of existing manufacturing processes. Experience in this field is desirable but consideration will be given to those applicants who by their present employment have proved themselves enterprising and progressive in their approach to machining, handling and process methods. For this position which has considerable scope and prospects a generous salary will be paid and assistance given with housing accommodation. A Pension Scheme is available. Write giving full details of age, training, experience with appointments held and present salary to: Box 1106, I.Prod.E., 10 Chesterfield Street, London, W.1.

Young Engineers. Glacier Metal Co. Ltd., has a few vacancies in its Technical Organisation for young engineers with honours degrees on variety of development work concerned with research into equipment, manufacturing processes and bearing design. Work involves mechanical design, hydrodynamics, automatic control theory, relaxation methods, etc. Candidates need not have specialised experience, but should be capable of accepting responsibility including possible control of subordinates, and be receptive to new techniques. Salary according to age and experience. Apply: Personnel Manager, Ealing Road, Alperton, Wembley, Middlesex.

General Manager. A small but expanding firm in S.E. England, engaged in the production primarily of plastic moulding tools and on an increasing scale of press tools for the engineering industry, invites applications for the post of General Manager. The position would be attractive to men seeking a long term, progressive appointment and prepared to work hard in developing a worthwhile project. Proven executive ability, particularly in expansion programmes, is essential; knowledge of plastic moulding techniques would be useful; engineering basic training, followed by considerable commercial experience, is a desirable background. Applications, detailing age, education and qualifications, all posts held, should be sent to: Box 211, Anderson & Co., 14 William IV Street, London, W.C.2.

Assistant Consultants. A. G. Hayek and Partners Limited, Management Consultants and Industrial Engineers, invite applications for vacancies for Assistant Consultants. Applicants should be of H.N.C. standard and must have had practical experience of Motion and Time Study, and Methods Engineering; some knowledge of Production Control and Costing an advantage. Appointments are based on Stoke-on-Trent. Participation in profit sharing scheme after completion of probationary period. Apply in confidence with fullest details and salary requirements to above at: Federation House, Stoke-on-Trent.

Management and Technical Staff. James A. Jobling & Co. Ltd., makers of "Pyrex" Laboratory, Scientific and Oven-Table Glassware in planning extensive expansion of their manufacturing activities, require to augment their management and technical staff and accordingly invite applications from: (a) Honours Graduates with engineering or science degrees, under 30 years of age who consider themselves ultimately capable of achieving a senior executive position. Selected candidates will be given a comprehensive training in the various activities of the Company with a view to appointment at Junior Management level. (b) Honours or pass Graduates with degrees in Physics or Mechanical Engineering, to take up appointments in the Research and Development Department. These vacancies offer wide scope and opportunities to young men having initiative and a broad outlook, with the possibility of transference to management positions. In all cases a commensurate salary is offered, contributory Pension Scheme. Write giving full particulars to: Personnel Department, James A. Jobling & Co. Ltd., Wear Glass Works, Sunderland.

Work Study Engineer. C. W. Martin & Sons Ltd., 61 Grange Road, London, S.E.1. Furskin Dressers & Dyers, have a vacancy for Work Study Engineer. The person envisaged would work under the general guidance of consultants in the implementation of an incentive scheme, and should be able to work unsupervised and take studies to the final stage of setting standards. Age range 24 years plus. Salary according to qualifications and previous experience. Applications should be addressed to: the Personnel Supervisor, at the above address.

Work Measurement Engineer. English Electric at Stafford, require experienced Work Measurement Engineer, capable of performing the following duties in a Works producing high quality, precision meters, relays and instruments. Production investigation: Time and Motion Study: Application of Incentive Schemes: Essential qualifications are an apprenticeship in one of the light engineering industries and subsequent experience in a production department, together with the technical standard of O.N.C. Assistance with housing will be offered where necessary. This is a permanent senior appointment, and the successful applicant will be eligible for entry into the Company's pension scheme. Applications are invited from engineers having the necessary qualifications and experience and should be addressed to: Dept. C.P.S., 336/7, Strand, W.C.2, quoting ref. 1224E.

Time and Motion Study Engineer. English Electric at Stafford, require experienced Time and Motion Study Engineer, capable of performing the following duties in a Works producing high quality, precision meters, relays and instruments. Production investigation: Time and Motion

MEETINGS

Visitors' tickets may be obtained from Section Honorary Secretaries.

JUNE, 1955

BIRMINGHAM **JUNE 25th**
Summer Outing.

EASTERN COUNTIES **7.30 p.m. JUNE 2nd**
Works visit to B.X. Plastics Ltd., Brantham Works, Suffolk.

EASTERN COUNTIES **2.0 p.m. JUNE 30th**
Works visit to Manganese Bronze & Brass Co. Ltd., Ipswich.

LINCOLN **7.0 p.m. JUNE 22nd**
Works visit to British Thomson-Houston Co. Ltd., Glass Works, Sheffield Road, Chesterfield.

NOTTINGHAM **9.30 a.m. JUNE 25th**
Works visit to Messrs. Boots Pure Drug Co. Ltd., Beeston.

READING **10.15 a.m. JUNE 23rd**
A works visit to C.V.A. Ltd., Acton, London.

WOLVERHAMPTON GRADUATE **9.30 a.m. JUNE 25th**
Works visit to Jaguar Motors, Coventry.

JULY MEETINGS

LINCOLN **6.30 p.m. JULY 13th**
Works visit to Messrs. Appleby-Frodingham Steel Co. Ltd., Scunthorpe.

PRODUCTION APPOINTMENTS

BULLETIN No. 57
JUNE 1955

The last date for receiving material for insertion in the following month's bulletin is the 20th of each month.

The fee for insertion of particulars regarding each appointment is £3 3s. (up to 100 words), and over 100 words £5 5s. A standard charge of £1 1s. per insertion is made to firms affiliated to the Institution, Technical Colleges, Universities and similar organisations.

Advertisers are advised that better response is likely if, in addition to essential qualifications, the following information is given:—

(*a*) Location of appointment; (*b*) Status in the organisation and scope of promotion; (*c*) Salary range and age range.

Advertisers are asked to advise the Institution when appointments are filled. The Institution reserves the right to refuse or withdraw any announcement and also to make any alteration in the wording to ensure conformity with the Institution standards. *Members interested in the following appointments should make application in accordance with the terms of notice. No correspondence can be undertaken by the Secretary other than the forwarding of replies to Box Nos.*

All advertisements appearing in this Bulletin are subject to the Notification of Vacancies Order of 1952.

Deputy Toolroom Superintendent. Hoover (Electric Motors) Limited, Cambuslang, Lanarkshire, have vacancy for a Deputy Toolroom Superintendent. Applicants must have a sound practical knowledge of toolroom work and have administrative experience suitable for a large toolroom associated with light electrical engineering. Range of work includes diecasting, single and multi-stage press tools, jigs, and fixtures. Candidates should be holders of the Higher National Certificate in Mechanical or Production Engineering. Assistance will be given with housing. Applications giving full details should be made in writing to: the Personnel Manager.

Production Controller, Senior Progress Engineers. The Aircraft Division of the Bristol Aeroplane Company have the following vacancies:— **Production Controller** for which applicants must have served an engineering apprenticeship, be fully experienced in all aspects of production control as applied to modern aircraft manufacture; and be capable administrators. **Senior Progress Engineers.** An engineering apprenticeship, and experience in aircraft production control and progress procedures are necessary qualifications. Applications, quoting *AIR 16* should give full details of education, qualifications and experience, and be addressed to: The Personnel Manager, The Bristol Aeroplane Company Limited, Aircraft Division, Filton House, Bristol.

Keen Mechanical Engineer with character and initiative required by well known and old established Company. Age 30/35, must have served apprenticeship and be a first-class engineer of proved ability, with practical experience in small quantity mass production, to ultimately take charge of small modern Works of 70 in country. The position is permanent and holds outstanding possibilities for advancement for keen and progressive man. Commencing salary £1,000 p.a. Write in confidence giving full particulars of experience, age, positions held, etc., to: Box No. 1103, I.Prod.E., 10 Chesterfield Street, London, W.1.

Junior Development Engineer. Venesta Limited require a Junior Development Engineer for their Collapsible Tube Factory at Silvertown for work connected with process and product development. Candidates should be about 25 years of age, have served a good engineering apprenticeship and preferably possess Higher National Certificate in Mechanical Engineering. Salary scale £600-£720. The starting salary within this grade will be according to qualifications and experience. Applications should include full details of qualifications and experience and be addressed to: the Personnel Manager, Venesta Limited, North Woolwich Road, E.16.

Qualified Engineering Staff. Attractive opportunities offered to experienced men with imagination and ability to advance with expanding organisation. International Company producing automotive transmissions. Modern factory, Hertfordshire: Welfare and superannuation schemes. Experience in automotive gear design would be an asset. 1M. Project Engineers, 2M. Section Leaders (Design), 3M. Design Draughtsmen. 4M. Junior Draughtsmen. Applications stating age, marital status, qualifications, availability and present salary, quoting appropriate reference number to: Box No. 1098, I.Prod.E., 10 Chesterfield Street, London, W.1.

Qualified Engineering Staff. Attractive opportunities offered to experienced men with imagination and ability to advance with expanding organisation. International Company producing automotive transmissions. Modern factory, Hertfordshire: Welfare and superannuation schemes. Experience in multi-machines and line production would be an asset: 5L. Production Engineers. 6L. Materials Controller. 7L. Plant Layout Draughtsmen. 8L. Planning and Process Engineers. Applications stating age, marital status, qualifications, availability and present salary, quoting appropriate reference number to: Box No. 1099, I.Prod.E., 10 Chesterfield Street, London, W.1.

Study: Application of Incentive Schemes: Essential qualifications are an apprenticeship in one of the light engineering industries and subsequent experience in a production department, together with the technical standard of O.N.C. Assistance with housing will be offered where necessary. This is a permanent senior appointment, and the successful applicant will be eligible for entry into the Company's pension scheme. Applications are invited from engineers having the necessary qualifications and experience and should be addressed to: Dept. C.P.S., 336/7, Strand, W.C.2, quoting ref. 1224D.

General Manager. Welding Electrode manufacturers require General Manager. Applicants must have had sound experience in the manufacture and use of electrodes, with proven administrative ability. All applications will be treated in the strictest confidence, and should state age, experience and salary required to: Director, Box No. 1107, I.Prod.E., 10 Chesterfield Street, London, W.1.

Planning Engineer required by large Company of electrical engineers situated in South London, with experience of preproduction planning of light electro-mechanical components. Applicants should have reached H.N.C. standard and possess a sound knowledge of production methods. Applications in confidence to: Box 3R. S5586. A.K. Advg., 212a Shaftesbury Avenue, London, W.C.2.

Senior Technical Engineers required. Weatherley Oilgear Limited, Biggleswade, Beds., invite applications to fill a number of senior technical engineers' posts in their Hydraulic Division. Some knowledge of the application of hydraulics to machinery will be an advantage—but this invitation is open to all those with design ability (not less than layout standard) of machinery, machine tools and the like equipment used in all industries. To men of proved ability, stability and enthusiasm, there is ample scope for progress. Applicants should give the fullest details of their career, qualifications, experience, age and present salary and address for attention of Managing Director.

Works Manager required medium sized engineering company London Wembley area engaged production high precision electronic equipment. Applicants must have sound executive and production experience in this or similar field including control of planning, estimating, methods and machine loading. Good shop floor experience both machine and assembly shops with ability to organise effectively to execute a programme on date and maintain firm control of personnel are essential. The post will command a four figure salary commensurate with qualifications. Applications preferred from experienced men under 45 years. Full particulars which will be treated as strictly confidential to: Box No. 1108, I.Prod.E., 10 Chesterfield Street, London, W.1.

Technical Liaison. Hoover Limited require an engineer for technical liaison between their factories in U.K. and overseas production units. Applicants should be experienced in modern engineering and mass production methods. Ability to speak French essential. Travel abroad involved. Commencing salary £800 plus generous bonus. Apply giving age, education and experience to: the Employment Officer, Hoover Limited, Perivale, Greenford, Middlesex. Telephone Perivale 3311 for further details.

Production Engineer. First class man required by expanding engineering Works in West of England. A recognised engineering diploma is essential and candidates should have the experience to develop and improve manufacturing methods, promote efficiency and reduce costs of a successful range of light and medium products. Only qualified men with extensive experience on Work Simplification and Measurement, incentives, methods and time study, tooling and estimating with wide knowledge of materials need apply. Position is progressive and pensionable. Age 30-40. State salary required to: Box No. 1109, I.Prod.E., 10 Chesterfield Street, London, W.1.

Superintendent, Hospital Limb and Instrument Workshop, required by Singapore Government Medical Department for tour of 3 years with prospect of pensionable employment. Salary scale (including expatriation pay and present variable allowance at rate for single men) equivalent to £1,412 rising to £2,002 a year. Additional variable allowance £113/182 a year (married men) and £113/294 a year (family men). Commencing salary according to experience. Free passages. Liberal leave on full salary. Candidates should hold a recognised diploma or certificate of proficiency in workshop and bench procedure and should have special knowledge of making orthopaedic appliances. They should also have a knowledge of woodwork, leatherwork, metalwork (including welding, recent plastics and their uses in orthopaedic surgery), and making artificial limbs. Write to: the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3B/33675/JL.

Production Controller. Applications are invited for the position of Production Controller with a company in South East Lancashire engaged in the manufacture of internal combustion engines. The successful applicant will be responsible for the co-ordination of progress, material control and stores sections of the company. Applicants must have at least three years' experience in a similar position and preference will be given to candidates who have been educated up to the Higher National Certificate in Production or Mechanical Engineering. The position is a permanent senior staff appointment and the company operates a contributory superannuation scheme. Applications should be as detailed as possible in connection with past experience and should be addressed to: Box No. 1110, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study and Time Study Engineers. The North British Rubber Co. Ltd., have vacancies at their Edinburgh Factory for: 1. **Work Study**—A trained engineer (age 23/33) with drawing office experience. Applicants should possess a degree or H.N.C. in Engineering and preferably some experience in methods study and layout planning. 2. **Time Study**—A trained Time Study Engineer (age 25/35). Applicants should have not less than three years practical experience and possess at least O.N.C. in Engineering. The positions are permanent, with good prospects, and pension scheme. Applications, giving age and full details of qualifications, education, experience and salary required to: Office Manager, North British Rubber Co. Ltd., Castle Mills, Edinburgh 3.

Works Manager. A progressive company (150 employees) in Surrey manufacturing electronic and scientific equipment require a Works and Production Manager. Applicants must have a sound engineering and administrative background and a knowledge of the electronic industry. A good salary and bonus will be paid to the right man and the position is pensionable. All applications will be treated in strict confidence, and should state age, qualifications, experience and salary expected to: Mervyn Instruments, Copse Road, St. John's, Woking, Surrey.

Methods Engineer required for improving trimming and machining operations on die-cast components. Must have practical and design experience, although not necessarily on die-castings and have passed Ordinary National Certificate. Age 20 to 25. Write stating full particulars to: the Personnel Manager, Joseph Lucas Limited, Formans Road, Sparkhill, Birmingham 11.

Machine Tool Sales & Service Engineer is required for India by a British Company with a Sales Organisation in that country. Applications are invited from men between the ages of 24-28 years, and preference would be given to a single man with experience in modern gear cutting practice. The employment would be on a 3-year contract basis on a salary commencing at £1,200 per annum payable in Indian currency with passage paid to and from India on the commencement and expiry of the contract, six months paid leave in the U.K. on completion thereof, also medical expenses and membership of Company's Provident Fund. The successful candidate would receive specialised training in U.K./U.S.A. prior to taking up the post in India. Box No. 1111, I.Prod.E., 10 Chesterfield Street, London, W.1.